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BREAKING STRENGTH AND ENDURANCE TESTING OF AIRCRAFT CONTROL CABLES

PERRY L. SMITH

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**SYSTEMS ENGINEERING GROUP
RESEARCH AND TECHNOLOGY DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO**

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FOREWORD

This report was prepared by the Directorate of Airframe Subsystems Engineering (SEFL), Systems Engineering Group, Wright-Patterson Air Force Base, Ohio. The reported tests were conducted during December 1966 and January 1967 in the Climatic Hangar at Eglin Air Force Base, Florida. Mr. Perry L. Smith (SEFL) was the project monitor for the evaluation program. This report was submitted by the author 5 April 1967.

This technical report has been reviewed and is approved.

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ABSTRACT

Because of recent high rejection rates on carbon steel control cables on military aircraft, the Air Force conducted breaking strength and endurance tests on various types of aircraft control cables. Since approximately 90% of the service life of jet aircraft is flown at low temperatures, the primary purpose of the tests was to obtain information on cable fatigue life at low temperature. The tests were conducted on 1/8-inch diameter 7x19 galvanized carbon steel, tin-coated carbon steel, and stainless steel cables at both low temperature (-65°F) and room temperature (+70°F). The tests were conducted in the Climatic Laboratory at Eglin AFB, Florida. Results indicate that the stainless steel cables are far superior to the galvanized or tin-coated cables for low temperature operation. Therefore, the stainless steel cables should be considered for replacement of the carbon steel control cables on military aircraft, and the appropriate specifications should be updated accordingly.

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SECTION I

INTRODUCTION

The failures of carbon steel control cables on military aircraft are serious problems in the Air Force. The life of these cables has decreased because of excessive wear in areas of the cable that contact pulleys and fairleads. Because of the high 1965-1966 rejection rate on carbon steel cables, the Air Force initiated an investigation of the various types of control cables used on Air Force aircraft. The program was to include the testing of stainless steel cables for possible replacement of carbon steel cables on these aircraft. A search of known literature indicated that all previous DOD testing of control cables had been performed at room temperature (approximately +70°F). Since jet aircraft potentially fly 90% of their service life at high altitudes and at low ambient temperatures, the primary purpose of the present investigation was to provide information on cable fatigue life at low temperature.

SECTION II

TESTS

The test program covered the testing of galvanized carbon steel, tin-coated carbon steel, and stainless steel cables. The requirements for the galvanized and tin-coated steel cables are given in Military Specification MIL-W-1511A-4, "Wire Rope, Steel (Carbon) Flexible, Performed." Military Specification MIL-C-5424A-1, "Cable: Steel (Corrosion-Resisting) Flexible, Performed (for Aeronautical Use)," gives the requirements for the stainless steel cables. Both of these specifications call for testing at room temperature only. The requirements of MIL-W-1511A-4 are more severe than those in MIL-C-5424A-1. The required breaking strength after endurance testing as given in the two specifications follows:

Specification	Cable diameter (inch)	Tension* (lbs)	Number of reversals	Breaking strength minimum (lbs)
MIL-W-1511A-4 (galvanized and tin-coated steel)	1/8	20	70,000	1000
MIL-C-5424A-1 (stainless steel)	1/8	20	150,000	950
*Tension is equal to one half of weight (W) which includes idler sheave and hanger.				

Both of these specifications require the cables to retain 50% of their breaking strength after the endurance testing.

Samples of 1/8-inch diameter 7x19 stainless, galvanized, and tin-coated steel cables were used in the test program. Seven different cable manufacturers submitted sample cables. These manufacturers are identified as Codes A through G in this report. Each manufacturer's samples were coded for identification and description. The galvanized and tin-coated steel cables were tested according to MIL-W-1511A-4, and the stainless steel cables were tested according to both MIL-W-1511A-4 and MIL-5424A-1.

The endurance tests were made on two standard Warner endurance machines. See Figures 1 through 3. These machines are described in both specifications.

The endurance tests were conducted at both low temperature (-65°F) and room temperature (+70°F). Samples numbered 1 through 4 represent those tested at -65°F, and samples numbered 5 through 8 represent those tested at +70°F.

Sixty-four assemblies (28 stainless steel, 28 galvanized carbon steel, and 8 tin-coated carbon steel) were tested to ascertain their breaking strength before they were subjected to the endurance testing. Each cable assembly consisted of one 3-foot cable section with one MS 21260-4 terminal swaged on each end. The assemblies were tested for breaking strength according to standard laboratory procedures in which a Baldwin tensile test machine was used. The assemblies were gripped by the shoulders of the terminal and loaded in tension until failure occurred. These tests were conducted at room temperature.

For the endurance tests, an equal number of samples from each manufacturer, in each type of steel submitted, were tested. Samples from each manufacturer were placed in a -65°F cold chamber for 2 hours before cycling. An equal number of samples were placed in a room at +70°F. Those samples tested according to MIL-W-1511A-4 were subjected to 70,000 reversals, and those tested according to MIL-C-5424A-1 were subjected to 150,000 reversals. The test cables were loaded to 20-pound tensile while cycling at a rate of 120 reversals per minute. The tests were limited to bending fatigue cycles while under tension. The complete scope of the cable problems as they exist today was not evaluated.

Each sample was subjected to endurance over top and bottom pulleys actually giving eight wear areas for inspection. Each sample was observed every 30 minutes for a period of 24 hours. Each was examined for its condition. The number of broken wires were recorded as they were noted.

All samples that completed the tests were pulled to destruction to determine the remaining strength after endurance.

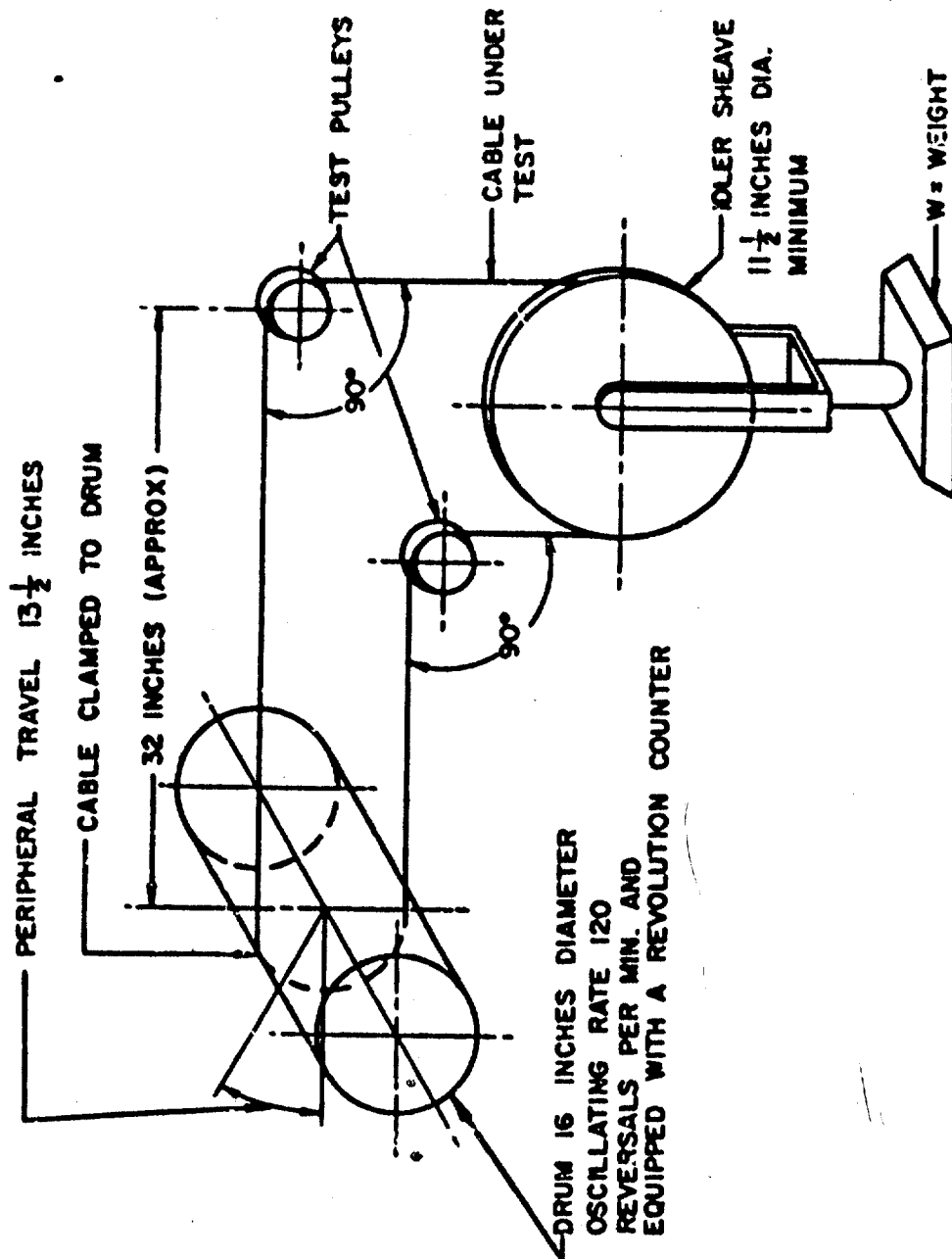


Figure 1. Schematic of Endurance Testing Machine



Figure 2. Test Setup for -65°F Endurance Testing

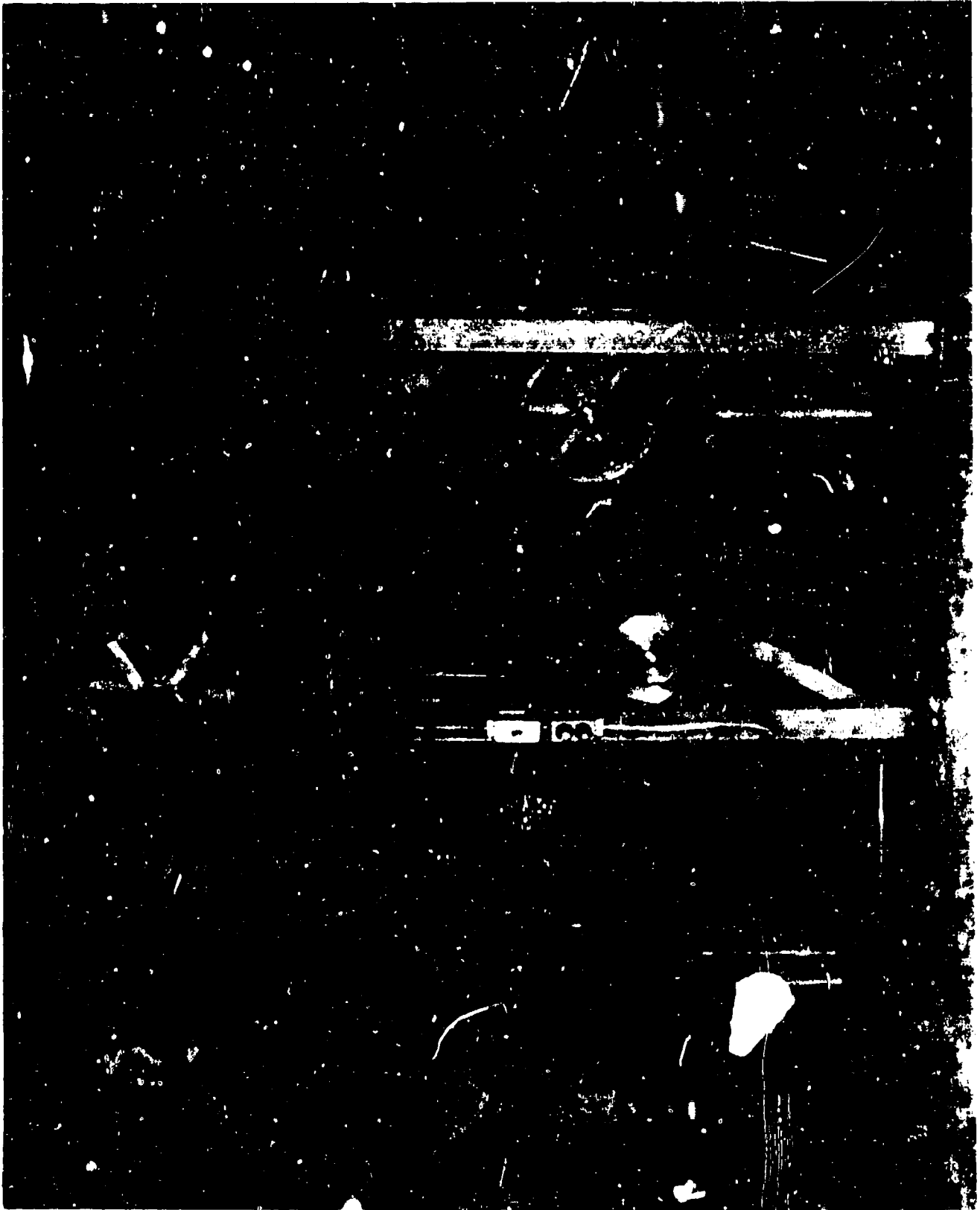


Figure 3. Test Setup for -70°F Endurance Testing

SECTION III

TEST RESULTS

Overall comparative test data obtained from the various samples and under various conditions are given in Appendix I (Tables I through IV and Figures 4 through 11). Detailed test data for each manufacturer (Codes A through G) are given in Appendixes II through VIII, respectively. The photographs show the damaged section of each sample which occurred when it was run over the pulleys. The beginning of wire breakage in the cables is indicated in Tables I through IV which substantiates the values shown in Figures 4 through 11.

TESTS AT -65°F

Of the cable samples which passed the MIL-W-1511A-4 tests, the percentage of breaking strength remaining for the stainless steel cable was substantially greater than that for the other two types. Galvanized cable from only two of the seven manufacturers passed the tests. See Figure 4. The test results on the tin-coated cables, submitted by only two manufacturers, showed a low level of performance. The tin-coated samples, however, passed the 50% requirement. See Figure 5. Six of the seven stainless steel samples met the severe endurance requirements of MIL-W-1511A-4. See Figure 6. All of the stainless steel cables submitted passed the MIL-C-5424A-1 endurance requirements. See Figure 7.

TESTS AT +70°F

The test data on the galvanized cables indicate that six of the seven manufacturers submitted satisfactory test results. See Figure 8. Both of the tin-coated control cables submitted for test are satisfactory for +70°F temperature operation. See Figure 9. Six of the seven manufacturers' stainless steel samples met the severe endurance requirements of MIL-W-1511A-4. See Figure 10. All stainless steel samples passed the MIL-C-5424A-1 endurance requirements. See Figure 11.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

Results indicate that the life of the stainless steel cables is far superior to galvanized or tin-coated carbon steel cables at low temperatures. Therefore, these cables should be considered for replacement of the carbon steel cables on military aircraft because of their superior corrosion resistance and longer life at low temperature.

Both Specifications MIL-W-1511A-4 and MIL-C-5424A-1 should be revised to include requirements for low-temperature fatigue testing. Also, the requirements for the allowable materials in MIL-W-1511A-4 and MIL-C-5424A-1 tables should be tightened by specifying chemical compositions.

APPENDIX I

OVERALL COMPARATIVE TEST DATA

TABLE I

NUMBER OF REVERSALS COMPLETED WHEN BROKEN WIRES WERE RECORDED FOR
GALVANIZED CABLES TESTED ACCORDING TO MIL-W-1511A-4

a. -65° F Tests

Sample No.		Manufacturer					
		A	B	C	D	E	G
1	T	32,500	19,200	26,200	21,600	17,800	25,000
	B	39,400	22,800	27,900	18,000	14,400	25,000
2	T	39,400	16,500	21,400	32,000	14,400	25,000
	B	35,900	16,500	26,200	10,000	10,900	25,000
3	T	35,900	19,200	26,200	38,000	17,800	25,000
	B	39,400	16,500	26,200	18,000	10,900	25,000
4	T	32,500	22,800	26,200	18,000	14,400	25,000
	B	35,900	16,500	26,200	28,000	17,800	25,000
Total		290,900	150,000	206,100	183,600	118,400	200,000
Average		36,362.5	18,750	25,762.5	22,950	14,800	25,000

b. +70° F Tests

5	T	43,600	21,300	46,200	36,000	21,500	14,300	14,800
	B	60,000	18,000	28,900	36,000	21,500	14,300	14,800
6	T	60,000	18,000	53,200	60,300	17,800	14,300	14,800
	B	60,000	18,000	53,200	60,300	25,200	32,000	26,000
7	T	60,000	21,300	49,200	52,700	21,500	32,000	26,000
	B	57,200	24,300	35,700	48,600	17,800	17,900	22,600
8	T	60,000	18,000	49,700	48,600	21,500	14,300	22,600
	B	43,600	28,500	32,000	39,000	25,200	32,000	22,600
Total		444,400	167,400	348,100	381,500	172,000	171,100	164,200
Average		55,550	20,925	43,512.5	47,687.5	21,500	21,387.5	20,525

T - Top pulley
B - Bottom pulley

TABLE II

NUMBER OF REVERSALS COMPLETED WHEN BROKEN WIRES WERE RECORDED
FOR TIN-COATED CABLES TESTED ACCORDING TO MIL-W-1511A-4

a. -65° F Tests

Sample No.		Manufacturer						
		A	B	C	D	E	F	G
1	T			25,000	30,800			
	B			25,000	30,800			
2	T			25,000	30,800			
	B			25,000	30,800			
3	T			25,000	30,800			
	B			25,000	30,800			
4	T			25,000	30,800			
	B			25,000	30,800			
Total				200,000	246,400			
Average				25,000	30,800			
b. +70° F Tests								
5	T			24,400	36,000			
	B			31,000	36,000			
6	T			24,400	52,800			
	B			28,000	36,000			
7	T			31,000	36,000			
	B			31,000	47,500			
8	T			28,000	49,400			
	B			34,000	32,400			
Total				231,300	326,100			
Average				28,975	40,762.5			
T - Top pulley B - Bottom pulley								

TABLE III

NUMBER OF REVERSALS COMPLETED WHEN BROKEN WIRES WERE RECORDED
FOR STAINLESS STEEL CABLES TESTED ACCORDING TO MIL-W-1511A-4

a. -65° F Tests

Sample No.		Manufacturer						
		A	B	C	D	E	F	G
1	T	19,200	21,700	54,110	41,700	23,800	16,500	26,500
	B	19,200	14,000	40,000	49,000	23,800	30,500	26,500
2	T	19,200	21,700	28,800	34,800	27,600	2,000	26,500
	B	22,800	14,000	40,000	49,000	27,600	16,500	38,000
3	T	29,900	21,700	64,700	38,300	23,800	30,500	33,000
	B	52,000	11,600	36,500	55,600	27,600	20,000	26,500
4	T	29,900	7,500	51,100	38,300	37,900	20,000	26,500
	B	37,000	21,700	50,600	31,400	23,800	20,000	38,000
Total		229,200	133,900	365,800	338,100	215,900	156,000	246,500
Average		28,650	16,737.5	45,725	42,262.5	26,987.5	19,500	30,812.5

b. +70° F Tests

5	T	28,900	18,400	16,200	42,000	25,100	6,500	14,500
	B	39,200	18,400	16,200	42,000	21,700	6,500	18,000
6	T	25,300	14,900	20,000	45,600	21,700	27,100	24,900
	B	32,200	11,000	27,400	38,300	28,700	27,100	18,000
7	T	25,300	18,400	27,400	42,000	18,000	13,300	21,700
	B	32,200	11,000	16,200	38,000	21,700	19,900	18,000
8	T	18,700	14,900	20,000	12,500	25,100	30,500	21,700
	B	25,300	14,900	16,200	31,400	21,700	27,100	7,200
Total		227,100	121,900	159,600	292,300	183,700	158,000	144,000
Average		28,387.5	15,237.5	19,950	36,537.5	22,962.5	19,750	18,000

T - Top pulley
B - Bottom pulley

TABLE IV

NUMBER OF REVERSALS COMPLETED WHEN BROKEN WIRES WERE RECORDED
FOR STAINLESS STEEL CABLES TESTED ACCORDING TO MIL-C-5424A-1

a. -65°F Tests

Sample No.	Manufacturer						
	A	B	C	D	E	F	G
1	T	26,000	35,700	150,000	100,500	47,300	25,200
	B	26,000	21,800	80,400	110,800	32,400	46,800
2	T	89,500	50,300	150,000	104,400	28,700	54,700
	B	89,500	39,500	89,100	145,900	65,600	46,800
3	T	26,000	50,300	30,900	150,000	75,600	36,700
	B	89,500	35,700	74,000	132,000	61,400	66,800
4	T	65,200	57,500	150,000	150,000	61,400	66,800
	B	68,000	28,600	67,000	110,000	54,300	60,100
Total		479,700	319,400	791,400	1,003,600	426,700	403,900
Average		59,962.5	39,925	98,925	125,450	53,337.5	50,487.5

b. +70°F Tests

5	T	22,500	31,000	57,820	53,000	66,700	70,000	19,500
	B	137,000	34,200	62,200	85,000	70,000	42,200	36,200
6	T	70,000	14,300	62,700	60,350	63,600	31,600	29,500
	B	46,500	34,200	62,700	37,900	66,700	48,500	57,600
7	T	28,700	24,500	36,100	71,000	42,000	76,900	47,800
	B	53,200	34,200	57,820	85,000	63,600	87,600	57,600
8	T	81,200	31,100	57,820	81,000	46,600	76,900	57,600
	B	56,700	29,500	57,820	81,000	50,000	52,900	47,800
Total		495,800	233,000	454,980	554,250	569,200	486,600	353,600
Average		61,975	29,125	56,872.5	69,281.25	71,150	60,825	44,200

T - Top pulley
B - Bottom pulley

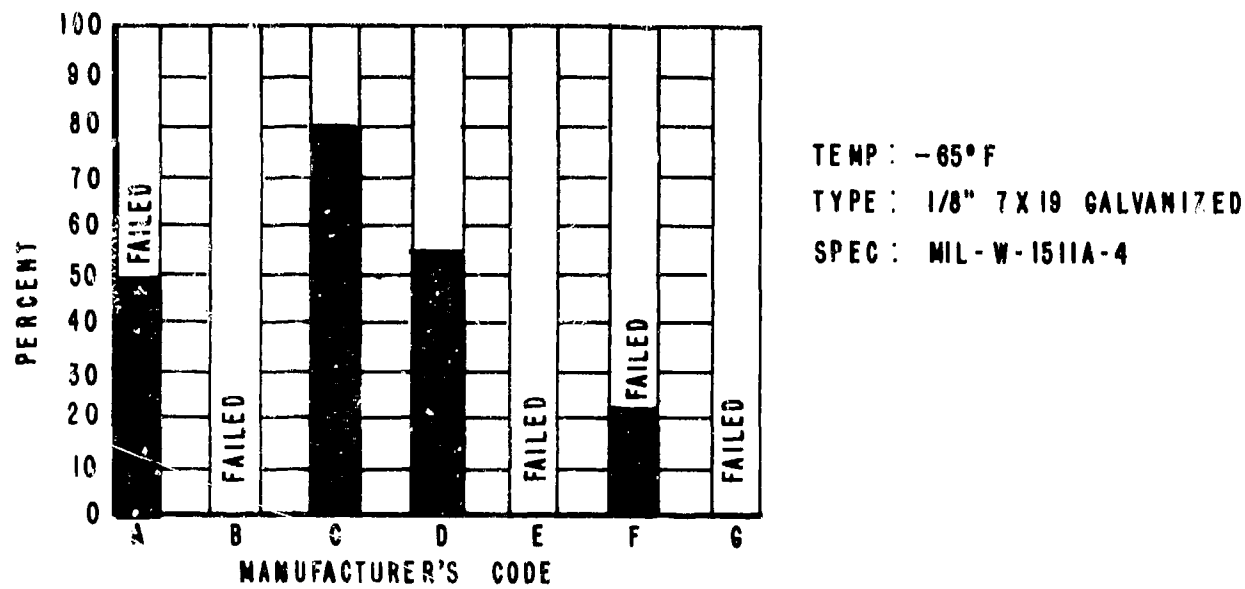


Figure 4. Average Percent of Breaking Strength Remaining After Endurance Tests of Top and Bottom Pulleys

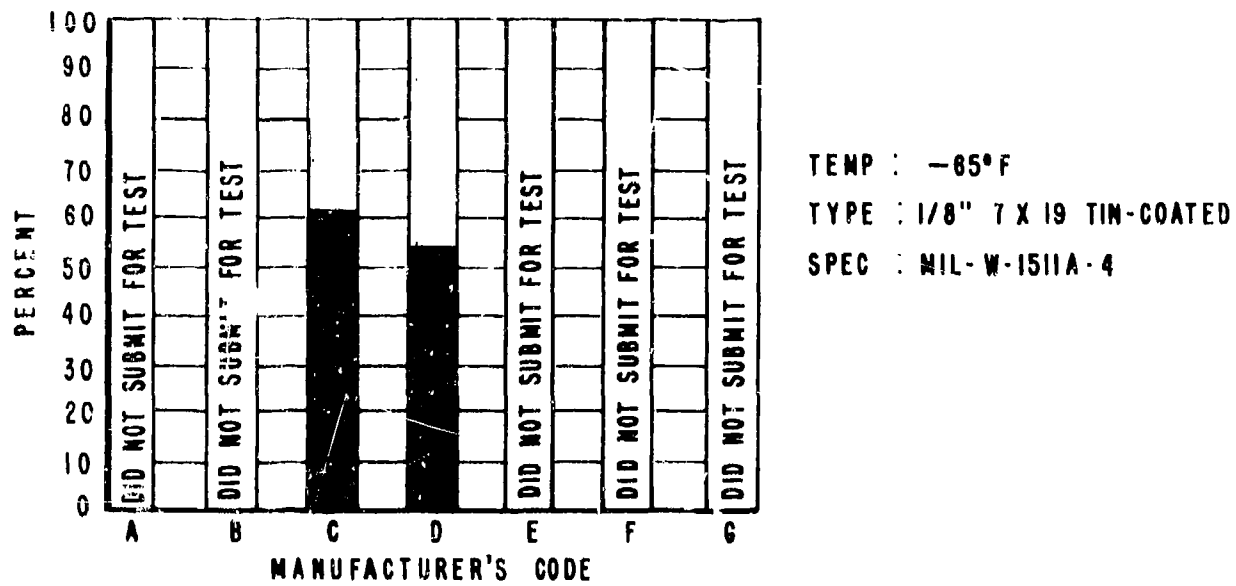


Figure 5. Average Percent of Breaking Strength Remaining After Endurance Tests of Top and Bottom Pulleys

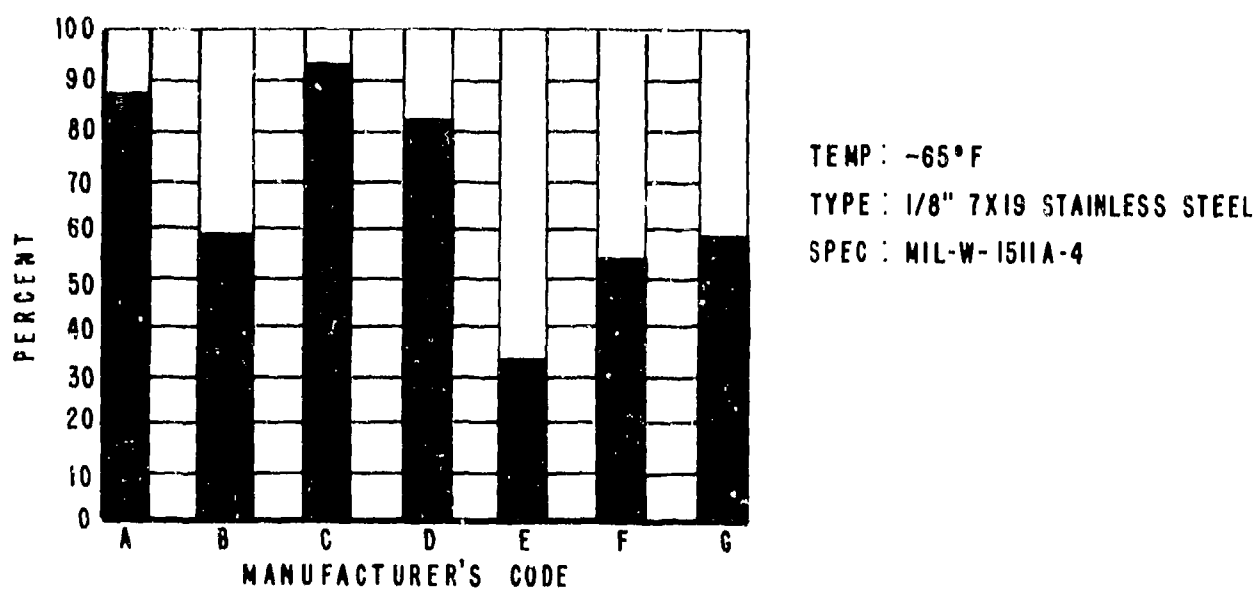


Figure 6. Average Percent of Breaking Strength Remaining After Endurance Tests of Top and Bottom Pulleys

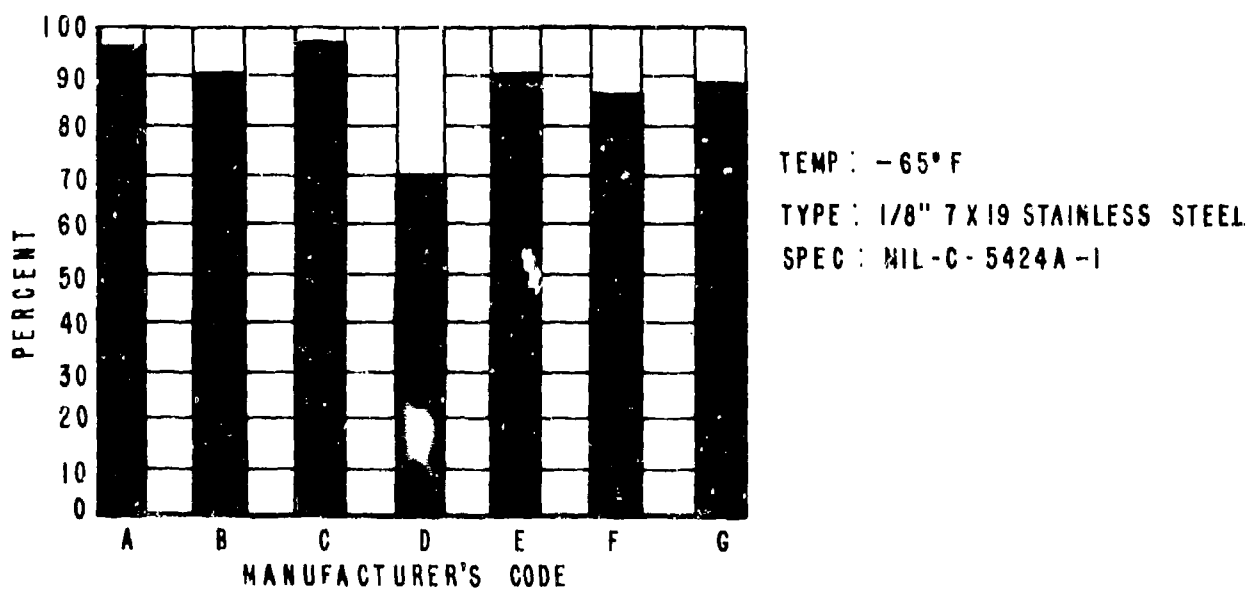


Figure 7. Average Percent of Breaking Strength Remaining After Endurance Tests of Top and Bottom Pulleys

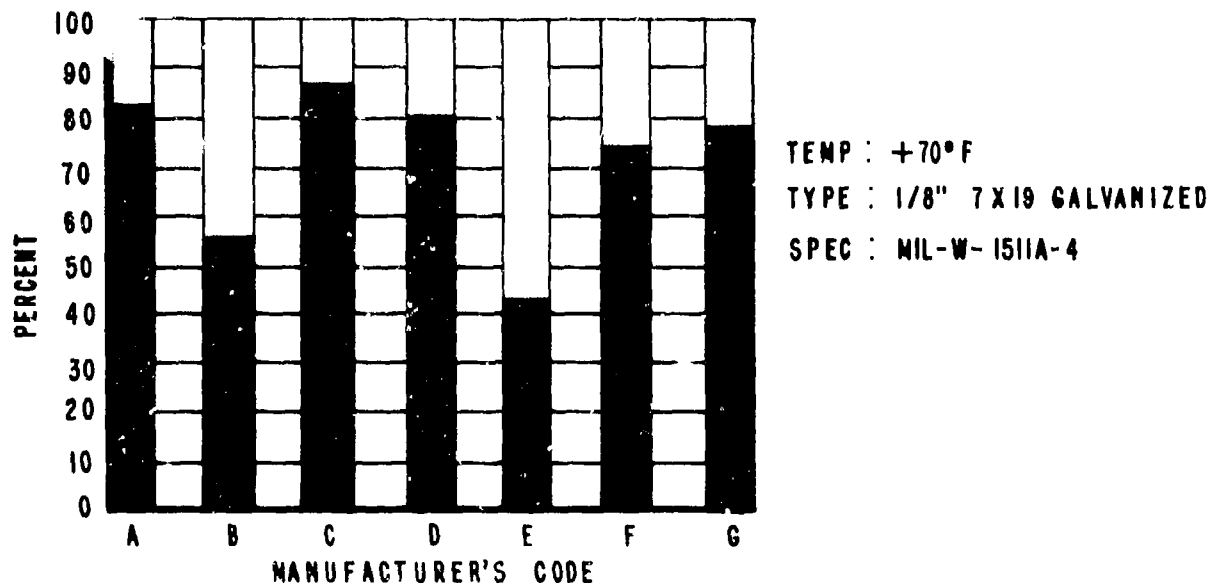


Figure 8. Average Percent of Breaking Strength Remaining After Endurance Tests of Top and Bottom Pulleys

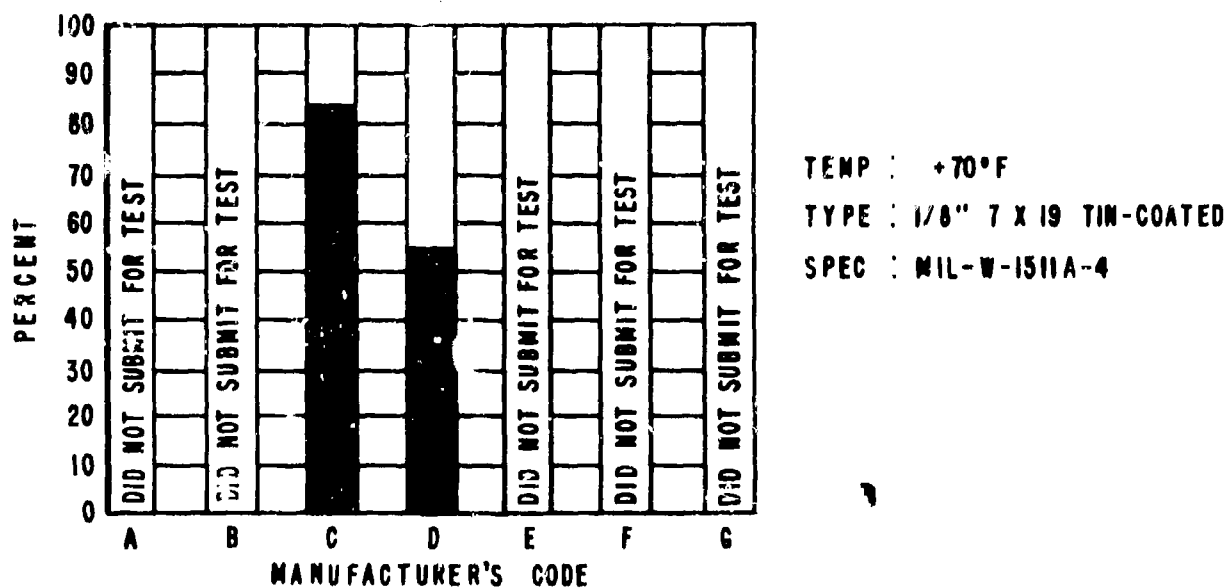


Figure 9. Average Percent of Breaking Strength Remaining After Endurance Tests of Top and Bottom Pulleys

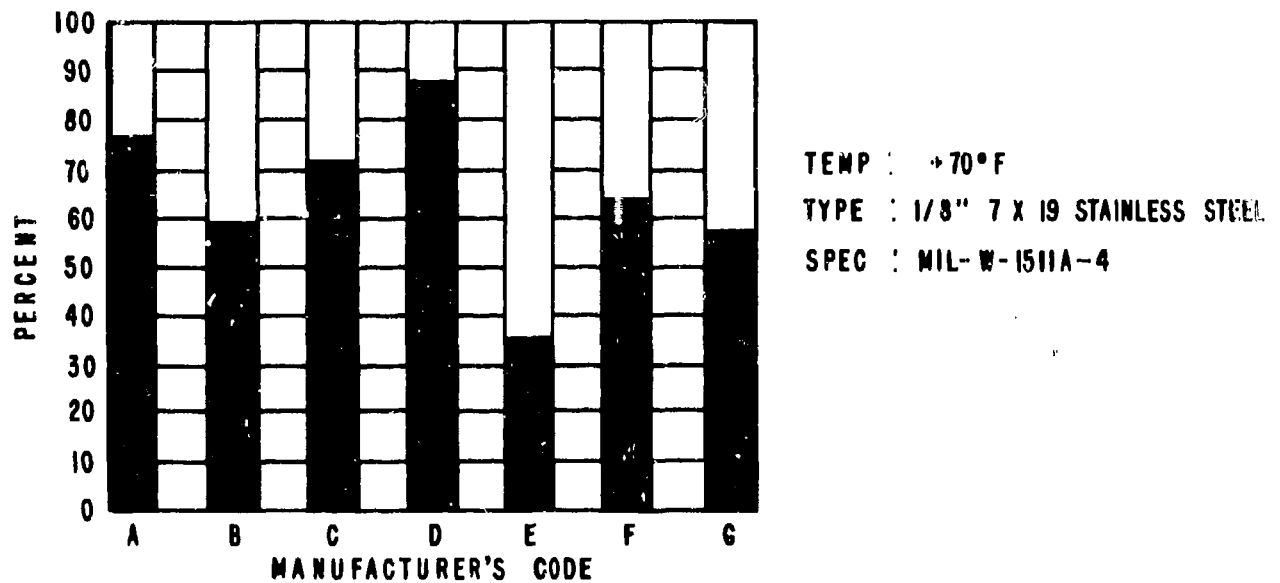


Figure 10. Average Percent of Breaking Strength Remaining After Endurance Tests of Top and Bottom Pulleys

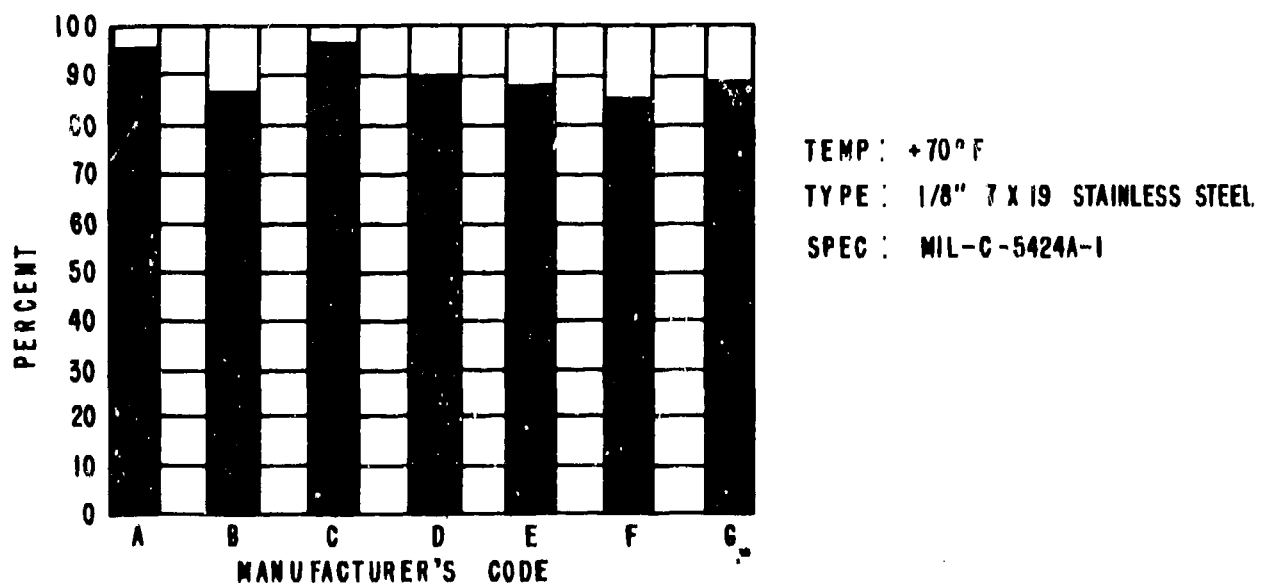


Figure 11. Average Percent of Breaking Strength Remaining After Endurance Tests of Top and Bottom Pulleys

APPENDIX II

DETAILED TEST DATA FOR CODE A

(Tables V through X and Figures 12 through 17)

In the figures for the -65°F tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 1

Sample 2

Sample 3

Sample 4

In the figures for the $+70^{\circ}\text{F}$ tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 5

Sample 6

Sample 7

Sample 8

TABLE V

BREAKING STRENGTH OF CODE A GALVANIZED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2150	1280	59.5	1150	53.5	x	
2	2175	1050	48.3	1030	47.4	x	
3	2200	885	40.2	1210	55.0		x
4	2175	1065	49.0	975	44.8		x
Total	8700	4280		4365			
Average	2175	1070	49.2	1091	50.2		



a. Top Pulley



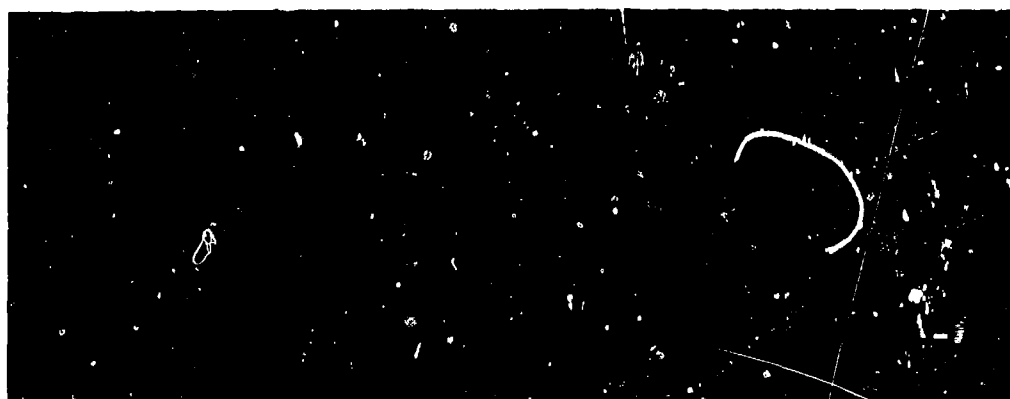
b. Bottom Pulley

Figure 12. Code A Galvanized Cable Endurance-Tested at -65°F to MIL-W-1511A-4.

TABLE VI

BREAKING STRENGTH OF CODE A GALVANIZED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2150	1710	79.5	1805	83.6	x	
6	2175	1850	85.1	1695	77.9	x	
7	2200	1725	78.4	1785	81.1	x	
8	2175	2035	93.6	1835	84.4	x	
Total	8700	7320		7120			
Average	2175	1830	84.1	1780	81.8		



a. Top Pulley



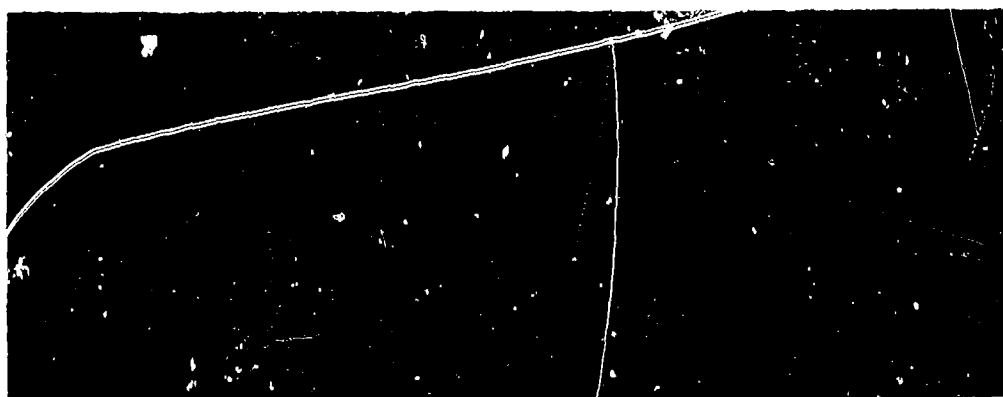
b. Bottom Pulley

Figure 13. Code A Galvanized Cable Endurance-Tested at +70°F to MIL-W-1511A-4

TABLE VII

BREAKING STRENGTH OF CODE A STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	1900	1600	84.2	1745	91.8	x	
2	1875	1750	93.3	1610	85.7	x	
3	1950	1745	89.5	1585	81.3	x	
4	1875	1750	93.3	1550	82.7	x	
Total	7600	6845		6490			
Average	1900	1711	89.0	1623	84.0		



a. Top Pulley



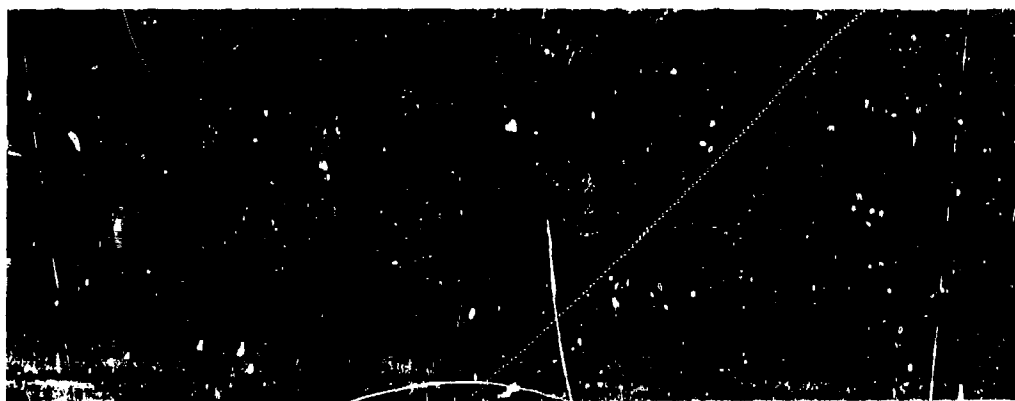
b. Bottom Pulley

Figure 14. Code A Stainless Steel Cable Endurance-Tested at -65°F to MIL-W-1511A-4

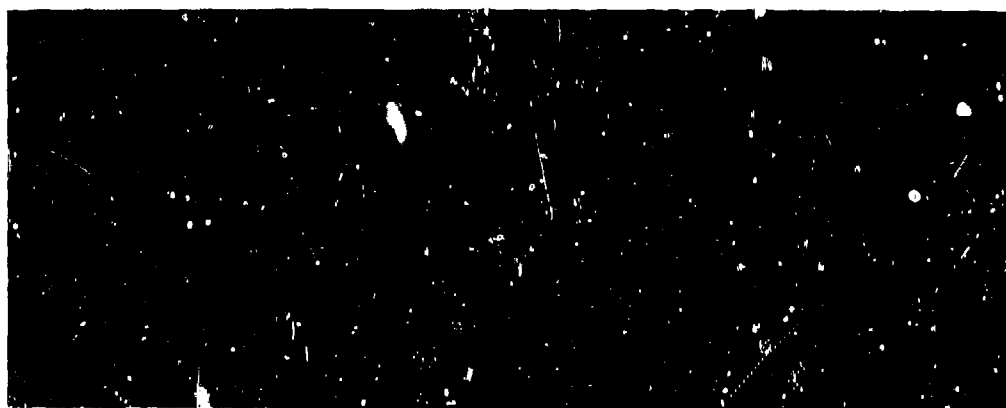
TABLE VII

BREAKING STRENGTH OF CODE A STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	1900	1555	81.8	1385	72.9	x	
6	1875	1420	75.7	1450	77.3	x	
7	1950	1505	77.2	1385	70.5	x	
8	1875	1570	83.7	1345	71.7	x	
Total	7600	6050		5565			
Average	1900	1513	79.6	1391	73.1		



a. Top Pulley



b. Bottom Pulley

Figure 15. Code A Stainless Steel Cable Endurance-Tested at +70°F to MIL-W-1511A-4

TABLE IX

**BREAKING STRENGTH OF CODE A STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-C-5424A-1**

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	1900	1860	97.9	1850	97.4	x	
2	1975	1905	96.5	1860	94.2	x	
3	1950	1885	96.7	1870	95.9	x	
4	1875	1850	98.7	1825	97.3	x	
Total	7700	7500		7405			
Average	1925	1875	97.5	1851	96.2		



a. Top Pulley



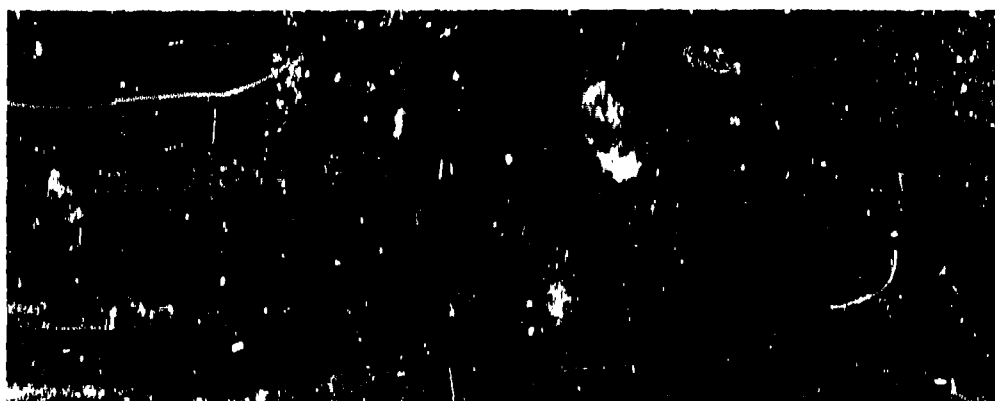
b. Bottom Pulley

Figure 16. Code A Stainless Steel Cable Endurance-Tested at -65°F to MIL-W-5424A-1

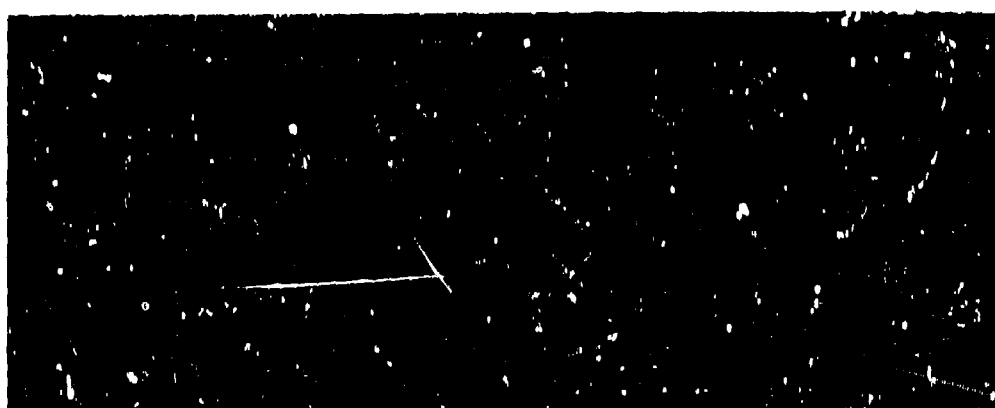
TABLE A

BREAKING STRENGTH OF CODE A STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-C-5424A-1

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	1945	1900	97.7	1895	92.8	x	
6	1975	1865	94.4	1905	96.5	x	
7	1950	1850	97.4	1935	99.2	x	
8	2045	1875	91.7	2025	99.0	x	
Total	7915	7580		7630			
Average	1979	1895	95.8	1907	96.4		



a. Top Pulley



b. Bottom Pulley

Figure 17. Code A Stainless Steel Cable Endurance Tested at +70°F to MIL-W-5424A-1

APPENDIX III

DETAILED TEST DATA FOR CODE B

(Tables XI through XVI and Figures 18 through 22)

Since galvanized samples failed the low temperature tests, no figures are included for these samples.

In the figures for the -65°F tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 1

Sample 2

Sample 3

Sample 4

In the figures for the $+70^{\circ}\text{F}$ tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 5

Sample 6

Sample 7

Sample 8

TABLE XI

BREAKING STRENGTH OF CODE B GALVANIZED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2475	Cables completely separated prior to 70,000 reversals. Tests were terminated.					X
2	2450						X
3	2460						X
4	2450						X
Total	9835						
Average	2459						

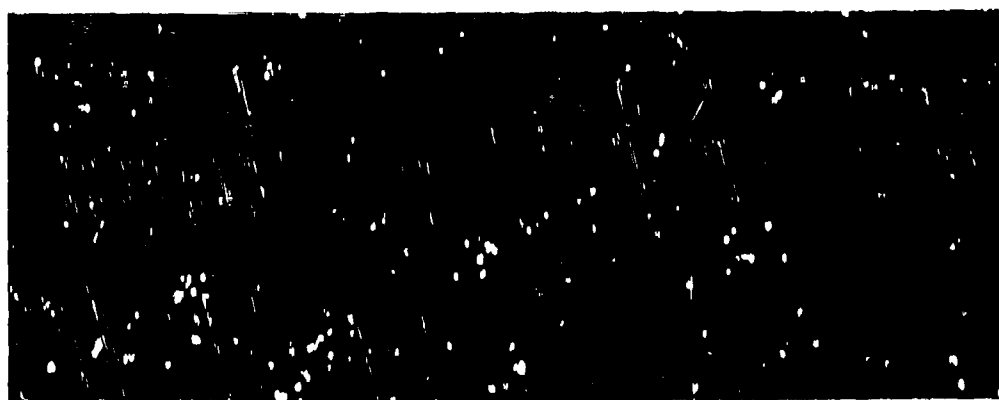
TABLE XII

BREAKING STRENGTH OF CODE B GALVANIZED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1551A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2475	1700	68.7	1180	47.7	x	
6	2450	1415	57.8	1450	59.2	x	
7	2460	1445	58.7	1395	56.7	x	
8	2450	1245	50.8	1315	53.7	x	
Total	9835	5805		5340			
Average	2459	1451	59.0	1335	54.3		



a. Top Pulley



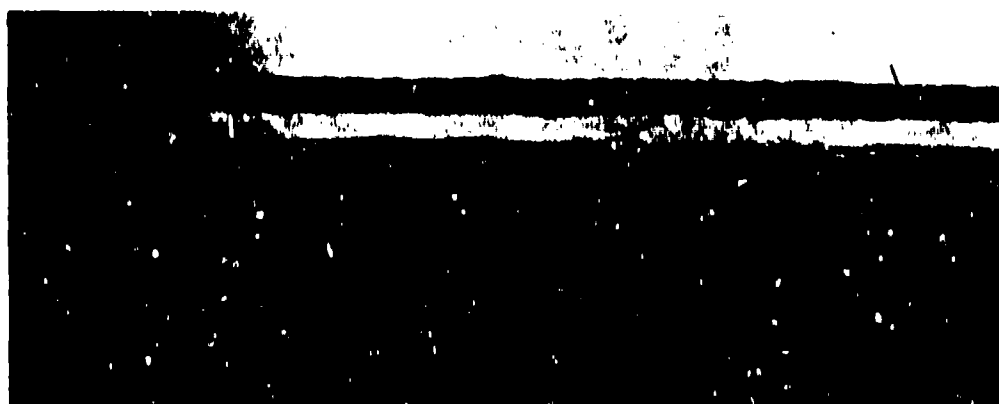
b. Bottom Pulley

Figure 18. Code B Galvanized Cable Endurance Tested at +70°F to MIL-W-1551A-4

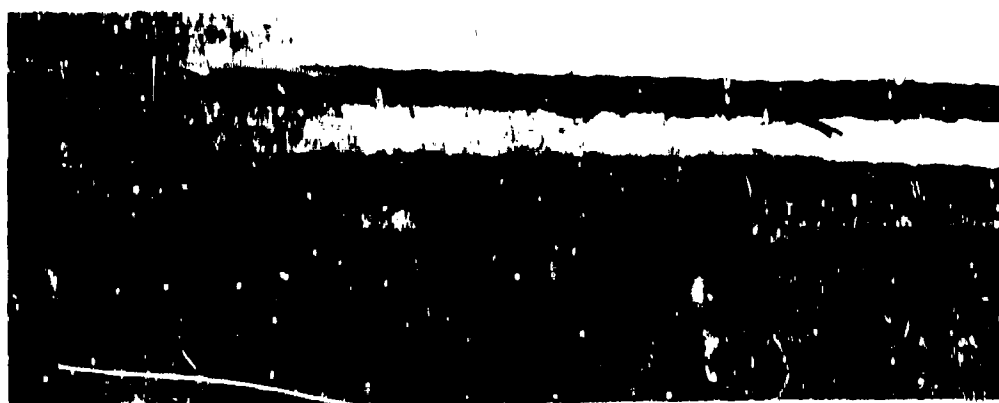
TABLE XII

BREAKING STRENGTH OF CODE B STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2260	1290	57.1	1470	65.0	x	
2	2250	1375	61.1	1200	53.3	x	
3	2240	1295	57.8	1345	60.0	x	
4	2240	1365	60.9	1325	59.2	x	
Total	8990	5325		5340			
Average	2248	1331	59.2	1335	59.4		



a. Top Pulley



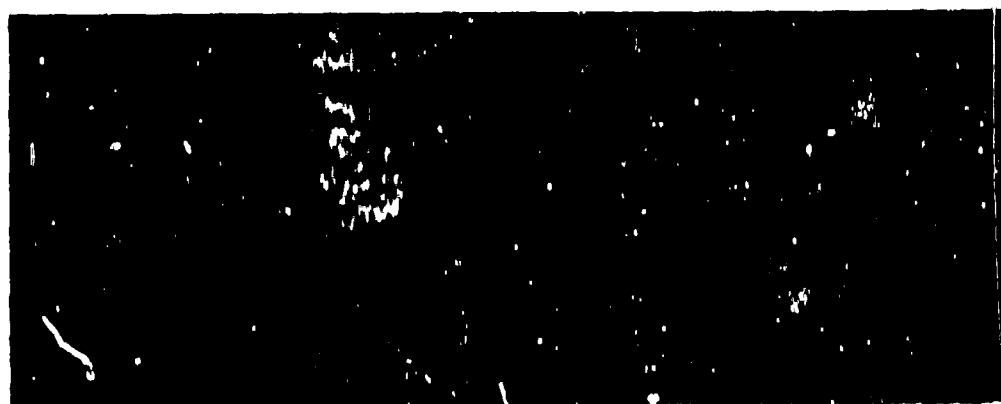
b. Bottom Pulley

Figure 19. Code B Stainless Steel Cable Endurance Tested at -65°F to MIL-W-1511A-4

TABLE XIV

BREAKING STRENGTH OF CODE B STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT 170°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2260	1375	59.2	1400	61.9	X	
6	2250	1325	60.8	1350	60.0	X	
7	2240	1300	58.9	1325	59.2	X	
8	2240	1275	58.0	1290	57.6	X	
Total	8990	5275	56.9	5365	59.7		
Average	2248	1319	58.7	1341	59.7		



a. Top Pulley



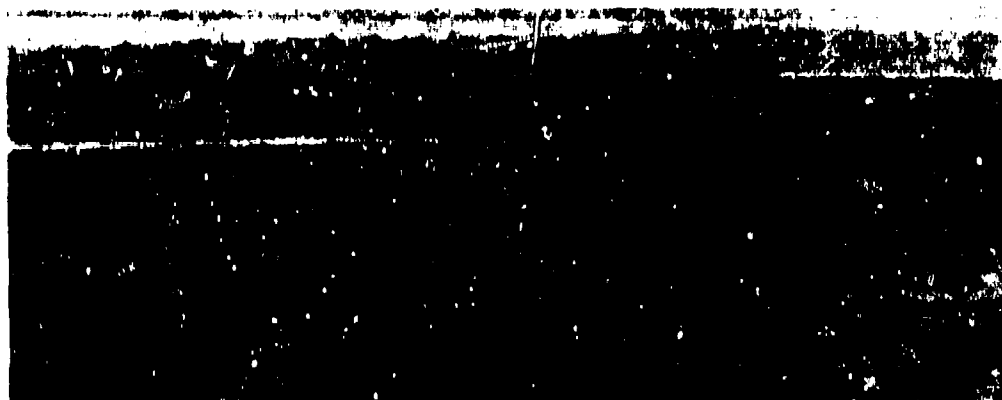
b. Bottom Pulley

Figure 20. Code B Stainless Steel Cable Endurance Tested at 170°F to MIL-W-1511A-4

TABLE XV

BREAKING STRENGTH OF CODE B STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-C-5424A-1

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2260	1970	87.2	2010	88.9	x	
2	2260	2085	92.7	2005	89.1	x	
3	2240	2120	94.6	1790	79.9	x	
4	2240	2155	96.2	2090	93.3	x	
Total	8990	8330		7895			
Average	2248	2083	92.6	1974	87.8		



a. Top Pulley



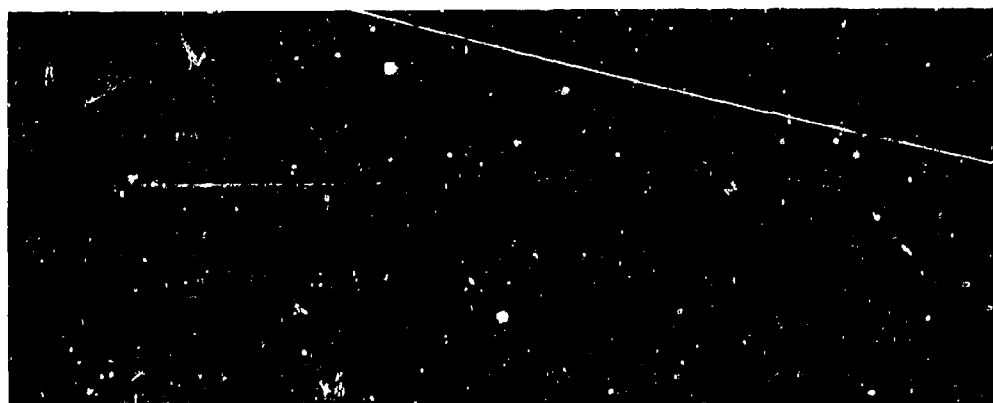
b. Bottom Pulley

Figure 21. Code B Stainless Steel Cable Endurance Tested at -65°F to MIL-C-5424A-1

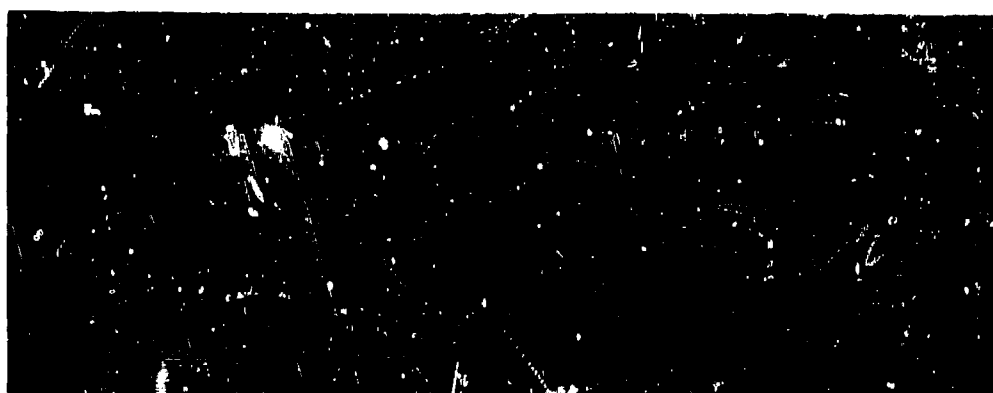
TABLE XVI

BREAKING STRENGTH OF CODE B STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-C-5424A-1

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2260	2125	94.0	1950	86.3	x	
6	2250	1935	86.0	1940	86.2	x	
7	2240	1910	85.3	2005	89.5	x	
8	2240	1805	80.6	1945	86.8	x	
Total	8990	1775		7840			
Average	2248	1944	86.5	1960	87.2		



a. Top Pulley



b. Bottom Pulley

Figure 22. Code B Stainless Steel Cable Endurance-Tested at +70°F to MIL-C-5424A-1

APPENDIX IV

DETAILED TEST DATA FOR CODE C

(Tables XVII through XXIV and Figures 23 through 30)

In the figures for the -65°F tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 1

Sample 2

Sample 3

Sample 4

In the figures for the $+70^{\circ}\text{F}$ tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 5

Sample 6

Sample 7

Sample 8

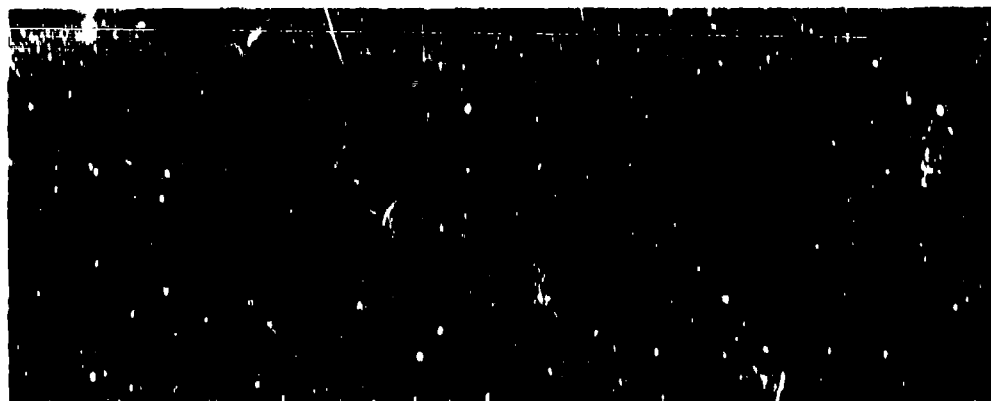
TABLE XVII

BREAKING STRENGTH OF CODE C GALVANIZED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2400	1970	82.1	2095	87.3	x	
2	2400	1990	82.9	1880	78.3	x	
3	2460	2105	85.6	1975	80.3	x	
4	2400	1620	67.5	1865	77.7	x	
Total	9660	7685		7815			
Average	2415	1921	79.6	1954	80.9		



a. Top Pulley



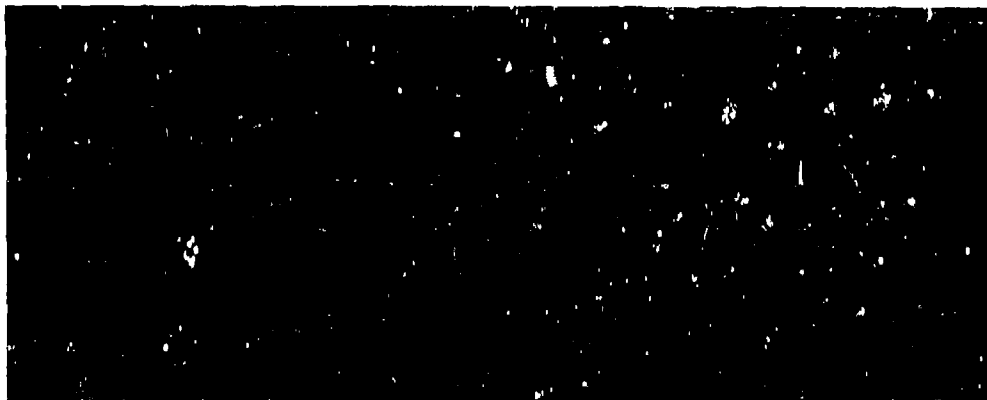
b. Bottom Pulley

Figure 23. Code C Galvanized Cable Endurance Tested at -65°F to MIL-W-1511A-4

TABLE XVIII

BREAKING STRENGTH OF CODE C GALVANIZED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2400	2250	93.8	2210	80.9	x	
6	2400	2070	86.3	2150	89.6	x	
7	2460	1920	78.0	2030	82.5	x	
8	2400	2130	88.8	2110	87.9	x	
Total	9660	8370		8500			
Average	2415	2090	86.6	2125	88.0		



a. Top Pulley



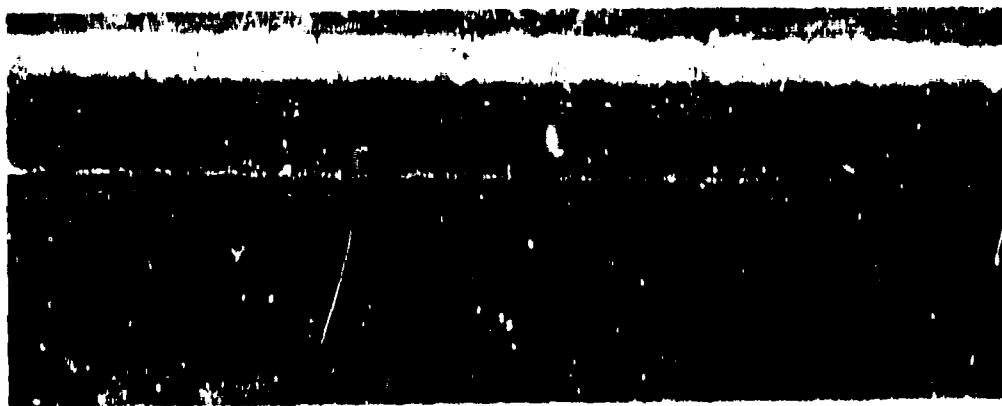
b. Bottom Pulley

Figure 24. Code C Galvanized Cable Endurance Tested at +70°F to MIL-W-1511A-4

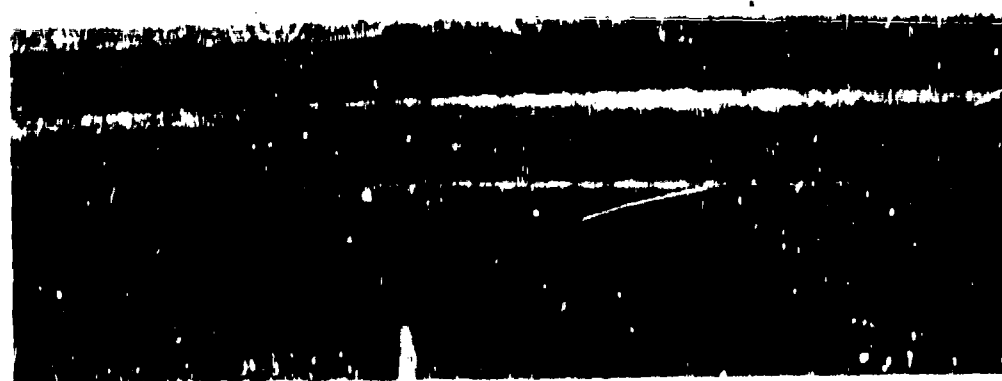
TABLE XIX

BRACING STRENGTH OF CODE C TIN-COATED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2460	1445	58.7	1585	64.7	X	
2	2470	1575	63.8	1530	61.9	X	
3	2480	1645	66.3	1595	64.3	X	
4	2470	1515	61.3	1445	58.5	X	
Total	9880	6180		6155			
Average	2470	1545	62.6	1539	62.3		



a. Top Pulley



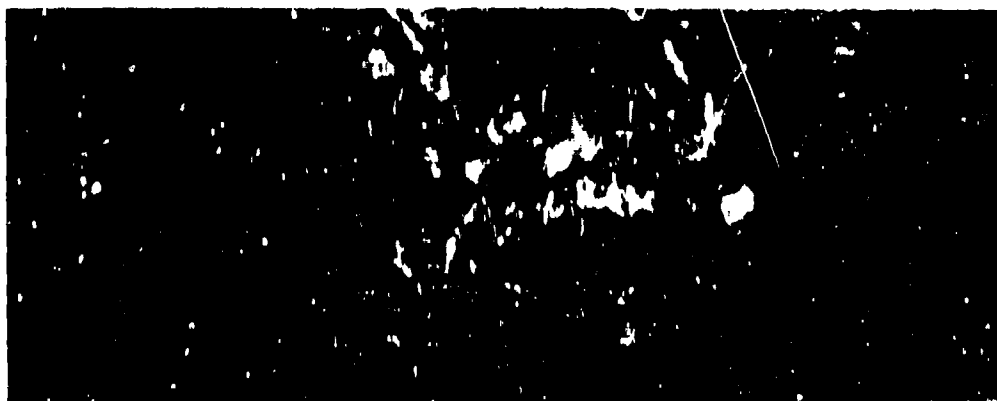
b. Bottom Pulley

Figure 25. Code C Tin-Coated Cable Endurance Tested at -65°F to MIL-W-1511A-4

TABLE XX

BREAKING STRENGTH OF CODE C TIN-COATED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2460	2105	85.6	2120	86.2	x	
6	2470	2100	85.0	2105	81.2	x	
7	2480	2070	83.5	2025	81.7	x	
8	2470	2100	87.0	1900	76.9	x	
Total	9880	8420		8050			
Average	2470	2106	85.3	2013	81.5		



a. Top Pulley



b. Bottom Pulley

Figure 26. Code C Tin-Coated Cable Endurance-Tested at +70°F to MIL-W-1511A-4

TABLE XXI

BREAKING STRENGTH OF CODE C STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	1940	1825	94.1	1780	91.8	x	
2	1980	1805	91.2	1850	93.4	x	
3	1960	1895	96.7	1785	91.1	x	
4	1960	1835	93.6	1775	90.6	x	
Total	7840	7360		7190			
Average	1960	1840	93.9	1798	91.7		

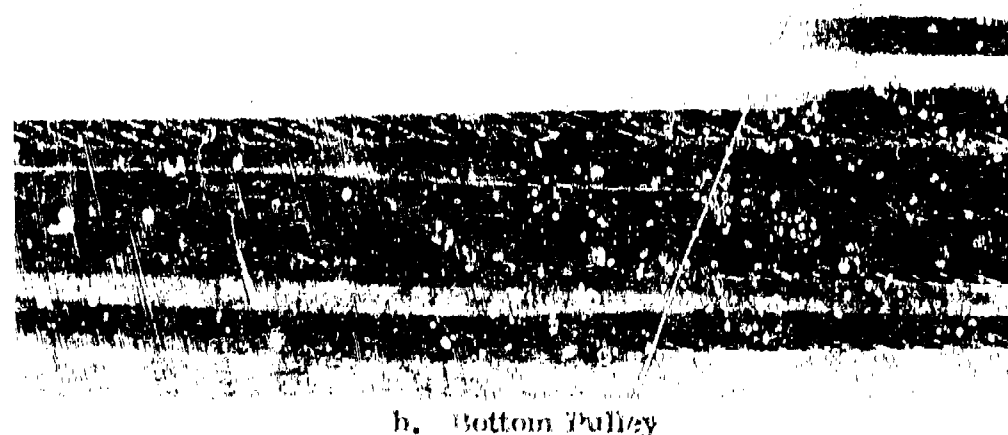
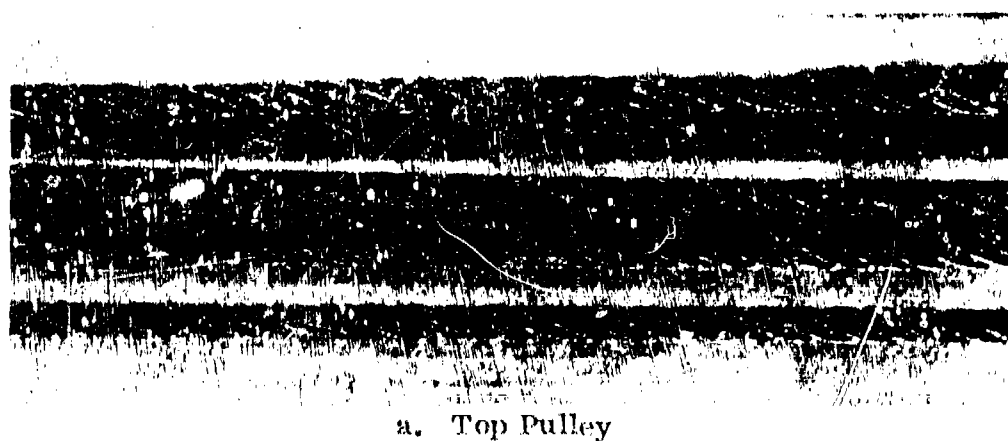
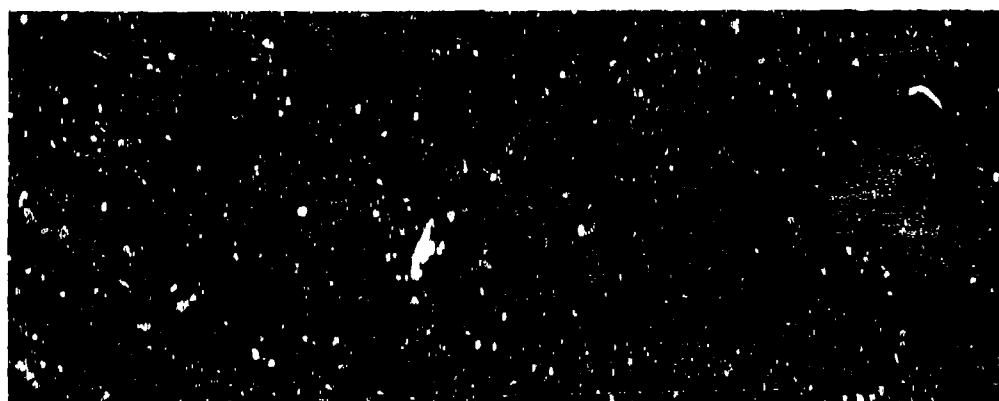


Figure 27. Code C Stainless Steel Cable Endurance-Tested at -65°F to MIL-W-1511A-4

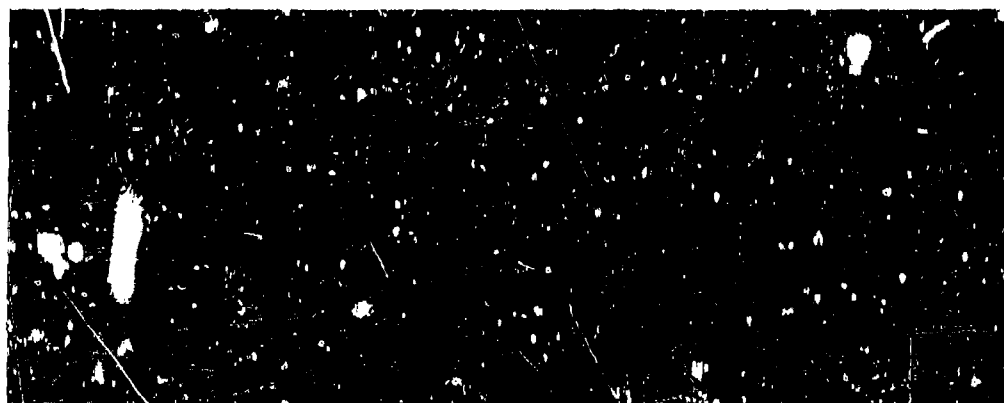
TABLE XXII

BREAKING STRENGTH OF CODE C STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	1940	1220	62.9	1450	74.7	x	
6	1980	1465	74.0	1675	85.0	x	
7	1960	1500	76.5	1255	64.0	x	
8	1960	1600	81.6	1100	56.1	x	
Total	7840	5785		5480			
Average	1960	1446	73.8	1370	69.9		



a. Top Pulley



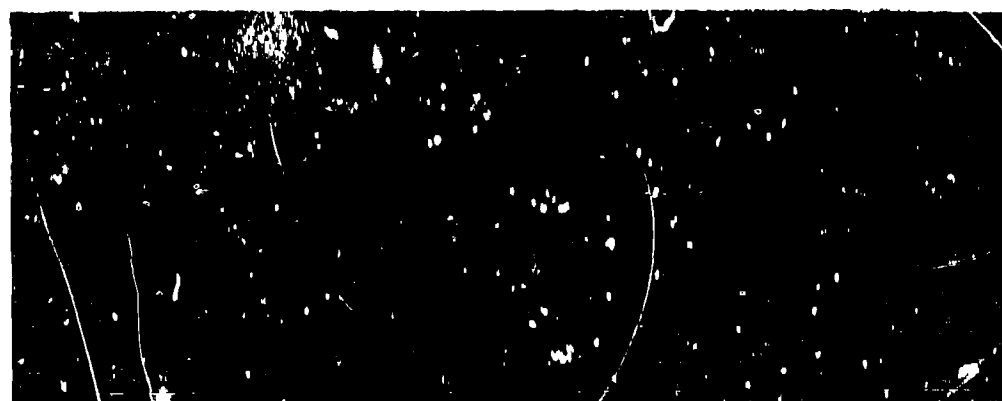
b. Bottom Pulley

Figure 23. Code C Stainless Steel Cable Endurance-Tested at +70°F to MIL-W-1511A-4

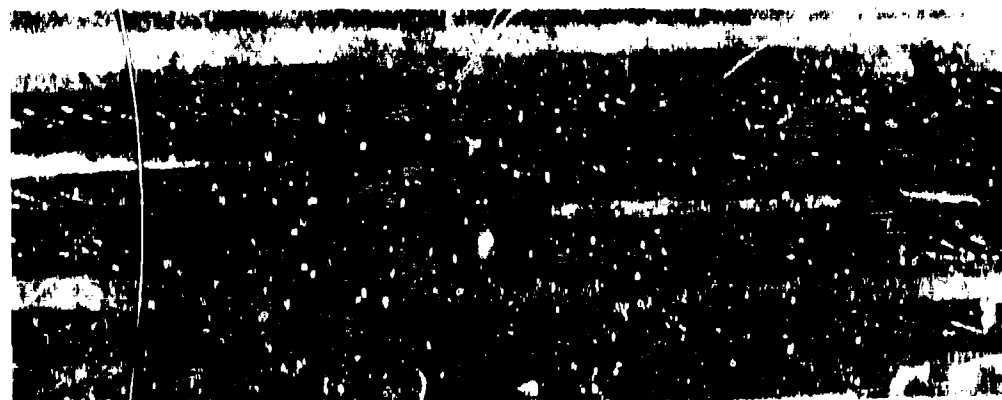
TABLE XXII

BREAKING STRENGTH OF CODE C STAINLESS STEEL CABLES BEFORE AND AFTER ENDURANCE TESTING AT -65°F TO MIL-C-5424A-1

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	1940	1915	98.7	1900	97.9	X	
2	1980	1910	96.5	1885	95.2	X	
3	1960	1915	97.7	1900	96.9	X	
4	1960	1920	98.0	1895	96.7	X	
Total	7840	7660		7580			
Average	1960	1915	97.7	1895	96.7		



a. Top Pulley



b. Bottom Pulley

Figure 29. Code C Stainless Steel Cable Endurance Tested at -65°F to MIL-C-5424A-1

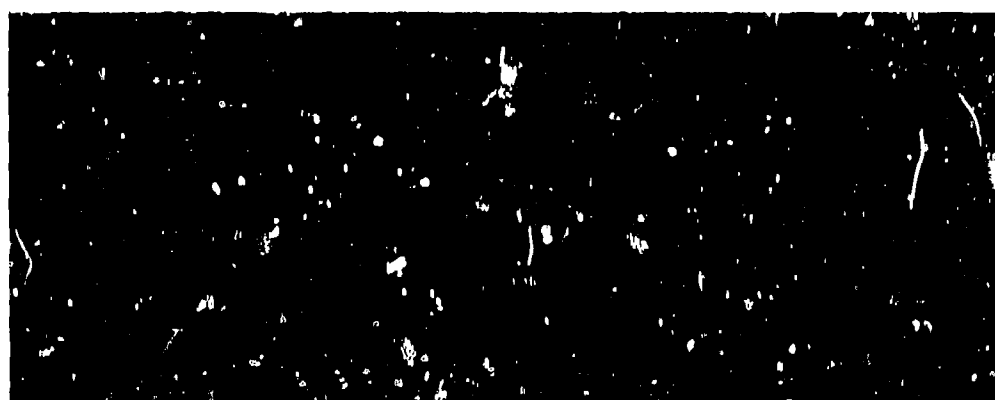
TABLE XXIV

BREAKING STRENGTH OF CODE C STAINLESS STEEL CABLES BEFORE AND AFTER ENDURANCE TESTING AT 470°F TO MIL-C-5424A-1

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	1940	1900	97.9	1915	98.7	X	
6	1980	1910	96.5	1885	95.2	X	
7	1960	1870	95.4	1900	96.9	X	
8	1960	1910	97.4	1920	98.0	X	
Total	7840	7690		7620			
Average	1960	1898	96.8	1905	97.2		



a. Top Pulley



b. Bottom Pulley

Figure 30. Code C Stainless Steel Cable Endurance Tested at 470°F to MIL-C-5424A-1

APPENDIX V

DETAILED TEST DATA FOR CODE D

(Tables XXV through XXXII and Figures 31 through 38)

In the figures for the -65°F tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 1

Sample 2

Sample 3

Sample 4

In the figures for the $+75^{\circ}\text{F}$ tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 5

Sample 6

Sample 7

Sample 8

TABLE XXV

BREAKING STRENGTH OF CODE D GALVANIZED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2300	1280	55.7	1220	53.0	X	
2	2360	1610	68.2	1185	50.2	X	
3	2360	1415	60.2	1495	63.6	X	
4	2360	1170	49.6	1000	42.4	X	
Total	9370	5475		4900			
Average	2343	1369	58.4	1225	52.3		



a. Top Pulley



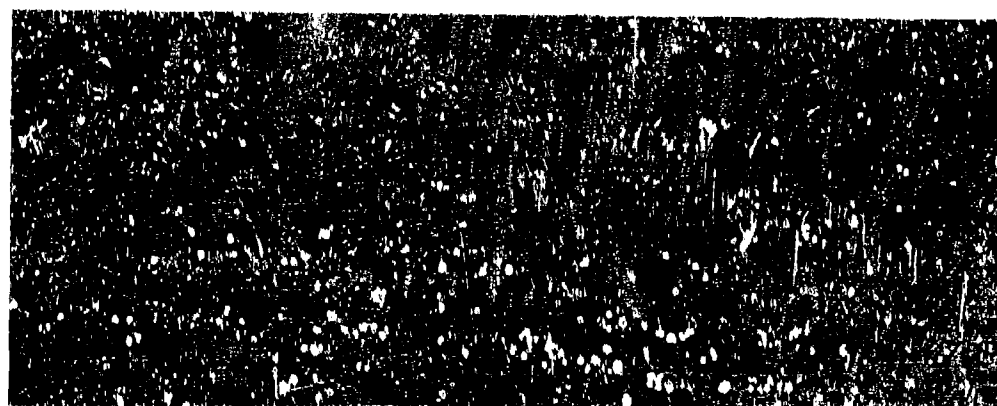
b. Bottom Pulley

Figure 31. Code D Galvanized Cable Endurance-Tested at -65°F to MIL-W-1511A-4

TABLE XXVI

BREAKING STRENGTH OF CODE D GALVANIZED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2300	1970	85.7	1870	81.3	X	
6	2360	1820	77.1	1980	84.0	X	
7	2350	1830	77.9	1890	80.4	X	
8	2360	1875	79.4	1990	84.3	X	
Total	9370	7495		7730			
Average	2343	1874	80.0	1932	82.5		



a. Top Pulley



b. Bottom Pulley

Figure 32. Code D Galvanized Cable Endurance Tested at +70°F to MIL-W-1511A-4

TABLE XXVII

BREAKING STRENGTH OF CODE D TIN-COATED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2260	1220	54.0	1250	55.3	X	
2	2300	1195	52.0	1220	51.0	X	
3	2280	1200	52.6	1150	50.4	X	
4	2300	1345	58.5	1300	56.5	X	
Total	9140	4960		4920			
Average	2285	1240	54.3	1230	51.8		



a. Top Pulley



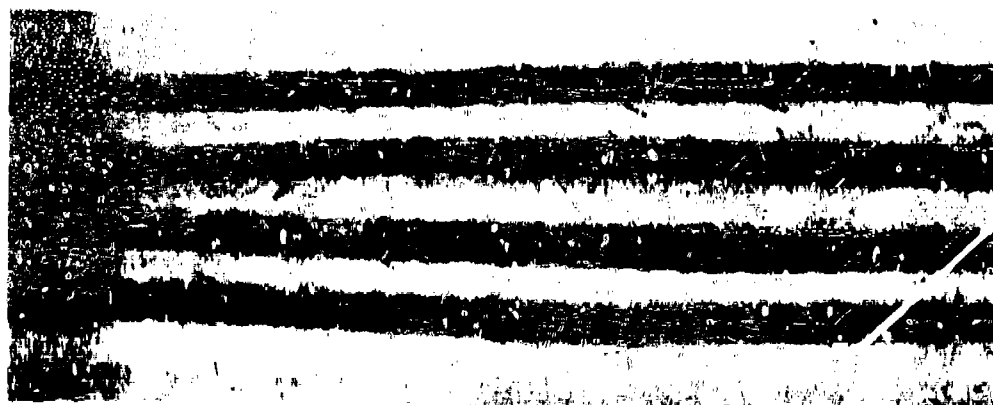
b. Bottom Pulley

Figure 33. Code D Tin-Coated Cable Endurance-Tested at -65°F to MIL-W-1511A-4

TABLE XXVIII

BREAKING STRENGTH OF CODE D TIN-COATED CABLES BEFORE AND AFTER ENDURANCE TESTING AT 170°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2260	1366	60.4	585	26.9		X
6	2300	1356	58.7	1060	46.7	S	
7	2280	1338	66.9	1506	66.0	X	
8	2300	1360	59.1	1230	53.5	X	
Total	9140	5600		4370			
Average	2285	1400	61.3	1093	47.8		



a. Top Pulley



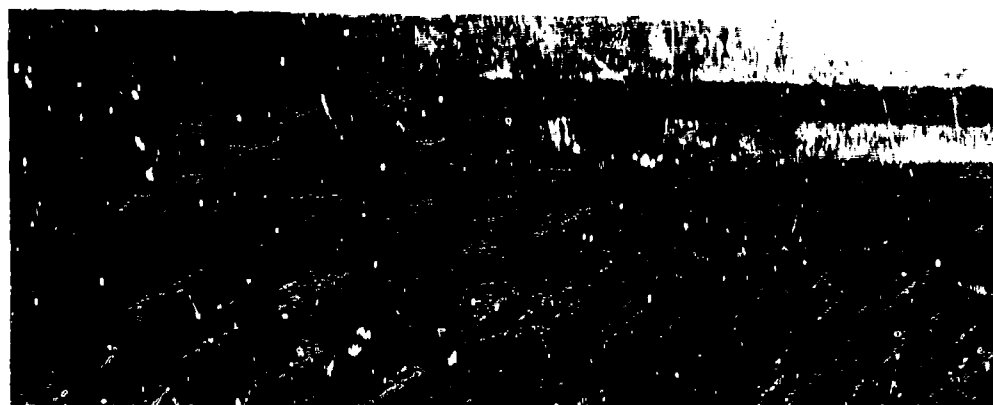
b. Bottom Pulley

Figure 34. Code D Tin-Coated Cable Endurance-Tested at 170°F to MIL-W-1511A-4

TABLE XXIX

BREAKING STRENGTH OF CODE D STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	1860	1650	83.3	1575	84.7	X	
2	1900	1560	82.1	1500	78.9	X	
3	1860	1620	87.1	1405	75.6	X	
4	1900	1625	86.6	1500	78.9	X	
Total	7620	6355		5980			
Average	1880	1589	84.6	1496	79.6		



a. Top Pulley



b. Bottom Pulley

Figure 35. Code D Stainless Steel Cable Endurance Tested at -65°F to MIL-W-1511A-4

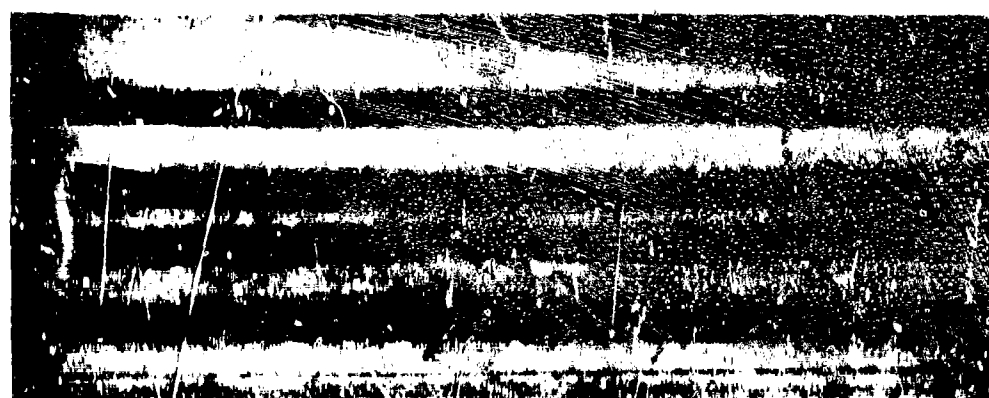
TABLE XXX

BREAKING STRENGTH OF CODE D STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT 170°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	1860	1440	77.4	1450	0	X	
6	1900	1515	79.7	1430	75.3	X	
7	1860	1415	79.3	1445	77.7	X	
8	1900	1410	74.2	1530	80.5	X	
Total	7620	5840		5865			
Average	1900	1460	77.7	1464	77.9		



a. Top Pulley



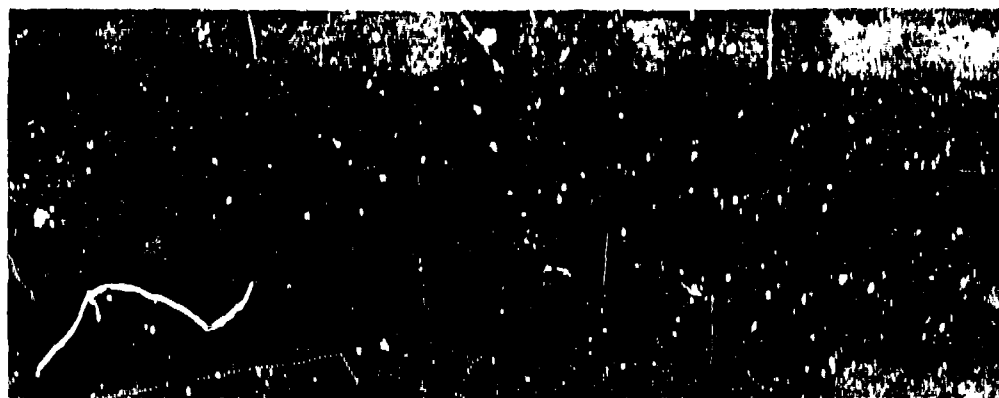
b. Bottom Pulley

Figure 36. Code D Stainless Steel Cable Endurance-Tested at 170°F to MIL-W-1511A-4

TABLE XXXI

BREAKING STRENGTH OF CODE D STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-C-5424A-1

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	1860	1575	84.7	1700	91.4	x	
2	1900	1745	91.8	1745	91.8	x	
3	1860	1660	89.2	1725	92.7	x	
4	1900	1645	86.6	1770	93.2	x	
Total	7520	6625		6940			
Average	1880	1656	88.1	1735	92.5		



a. Top Pulley



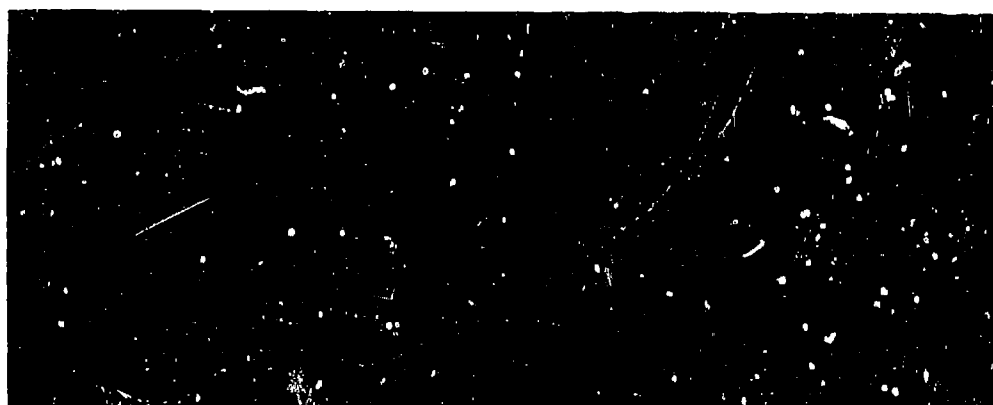
b. Bottom Pulley

Figure 37. Code D Stainless Steel Cable Endurance Tested at -65°F to MIL-C-5424A-1

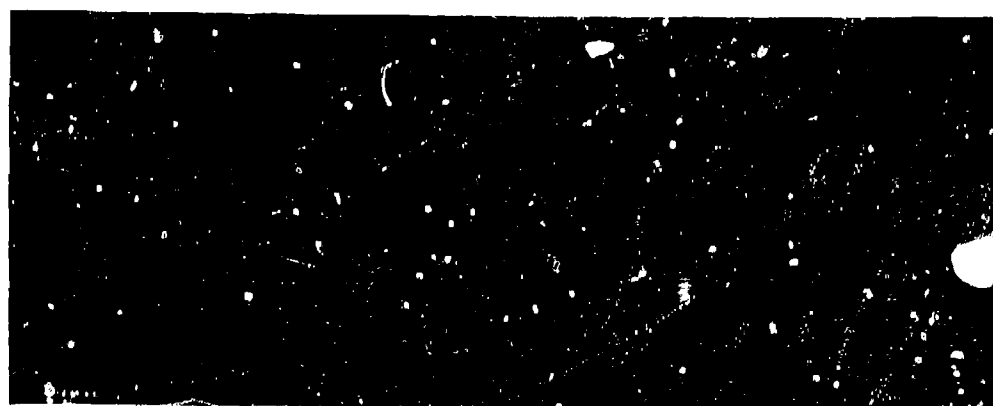
TABLE XXXII

BREAKING STRENGTH OF CODE D STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70° F TO MIL-C-5424A-1

SAMPLE NO	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	1960	1800	91.8	1875	95.7	x	
6	1900	1685	88.7	1665	87.6	x	
7	1860	1675	90.1	1700	91.4	x	
8	1900	1705	89.7	1705	89.7	x	
Total	2620	6865		6945			
Average	1905	1716	90.1	1736	91.1		



a. Top Pulley



b. Bottom Pulley

Figure 38. Code D Stainless Steel Cable Endurance-Tested at +70° F to MIL-C-5424A-1

APPENDIX VI
DETAILED TEST DATA FOR CODE E

(Tables XXXIII through XXXVIII and Figures 39 through 45)

Since galvanized samples failed the low temperature tests, no figures are included for these samples.

In the figures for the -68°F tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 1

Sample 2

Sample 3

Sample 4

In the figures for the $+70^{\circ}\text{F}$ tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 5

Sample 6

Sample 7

Sample 8

TABLE XXXIII

**BREAKING STRENGTH OF COOR & GALVANIZED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65° TO MIL-W-1811A-4**

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2060	Cables completely separated prior to 70,000 reversals. Tests were terminated.					X
2	2360						X
3	2380						X
4	2360						X
Total	9160						
Average	2290						

TABLE XXXIV

BREAKING STRENGTH OF CODE E GALVANIZED CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1690 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2060	1125	54.6	795	38.6		x
6	2360	975	41.3	960	40.7		x
7	2380	725	30.5	1110	46.6		x
8	2360	1065	45.1	1140	48.3	x	
Total	9160	3890		4005			
Average	2290	973	42.5	1001	43.7		



a. Top Pulley



b. Bottom Pulley

Figure 39. Code E Galvanized Cable Endurance-Tested at +70°F to MIL-W-1511A-4

TABLE XXIV

BREAKING STRENGTH OF CODE E STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1700 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (800 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2000	470	23.5	550	27.5	x	x
2	1980	900	48.1	975	49.2		x
3	1975	950	48.1	1090	55.2		
4	1980	Test No. 4 completely separated prior to 70,000 reversals. Tests were terminated.					
Total	7935	2320		2615			
Average	1984	773	29.2	872	33.0		



a. Top Pulley



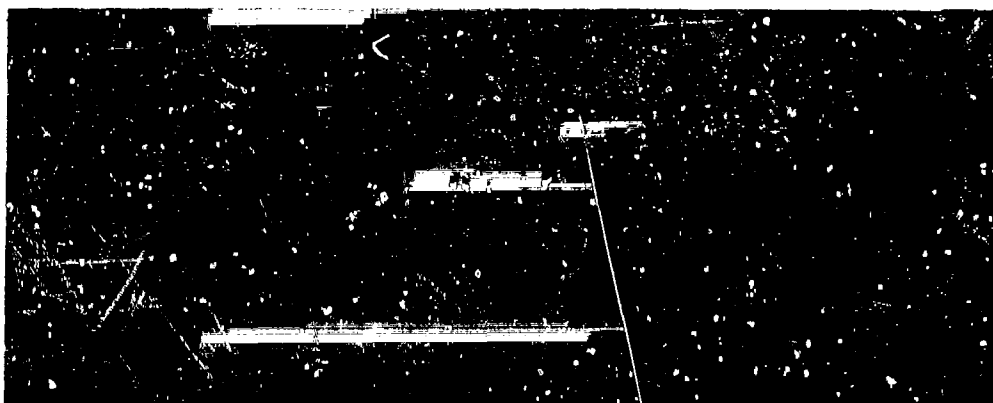
b. Bottom Pulley

Figure 40. Code E Stainless Steel Cable Endurance-Tested at -65°F to MIL-W-1511A-4

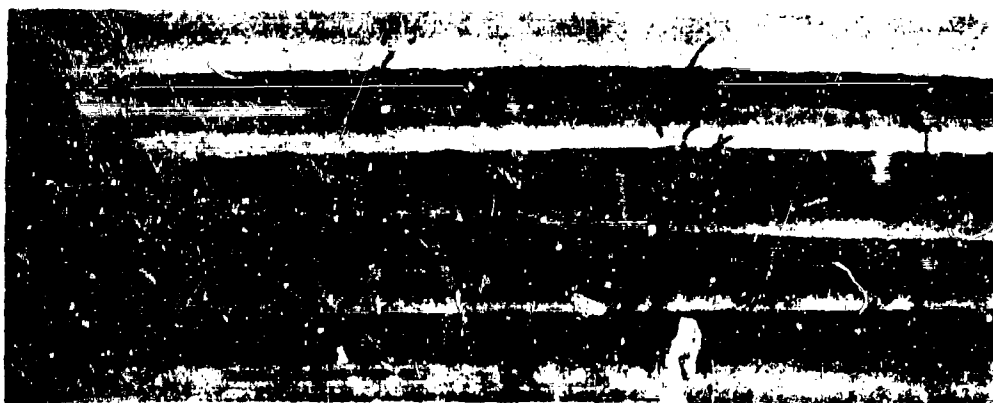
TABLE XXVI

WEARING STRENGTH OF CODE E STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO	POUNDS BEFORE ENDURANCE TESTING (1700 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2000	475	23.8	590	29.5		x
6	1980	765	38.6	970	49.0		x
7	1975	815	41.3	622	31.5		x
8	1980	900	45.5	610	30.8		x
Total	7935	2955		2792			
Average	1984	739	37.2	698	35.2		



a. Top Pulley



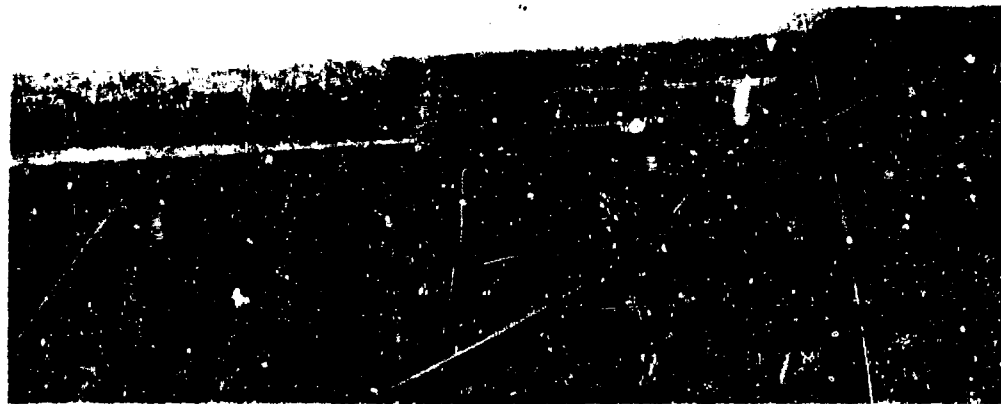
b. Bottom Pulley

Figure 41. Code E Stainless Steel Cable Endurance-Tested at +70°F to MIL-W-1511A-4

TABLE XXXVII

**BREAKING STRENGTH OF CODE E STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-C-5424A-1**

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2000	1355	67.8	1380	69.0	x	
2	1980	1285	64.9	1185	59.8	x	
3	1975	1025	51.9	1445	73.2	x	
4	1980	1625	82.1	1750	88.4	x	
Total	7935	5290		5760			
Average	1984	1323	66.7	1440	72.6		



a. Top Pulley



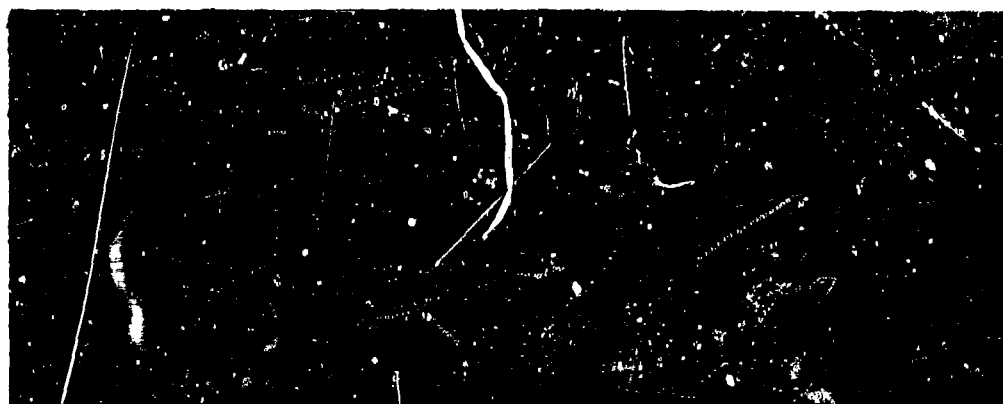
b. Bottom Pulley

Figure 42. Code E Stainless Steel Cable Endurance-Tested at -65°F to MIL-C-5424A-1

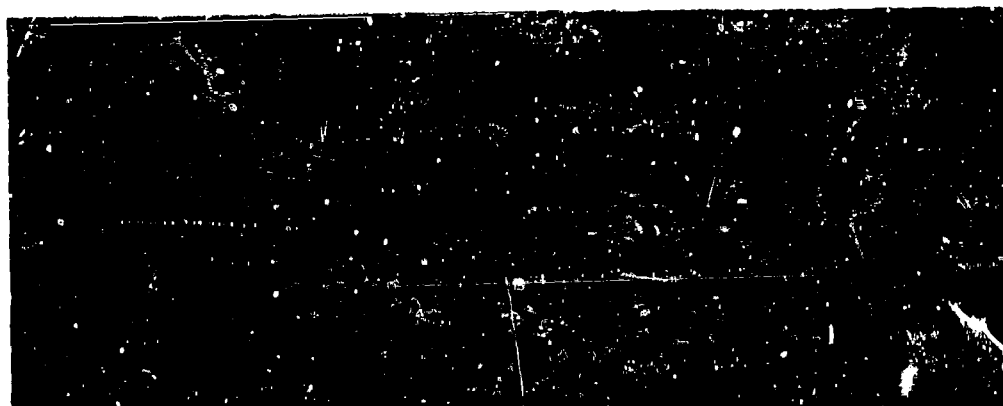
TABLE XXVIII

BREAKING STRENGTH OF CODE E STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-C-5424A-1

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1880 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2000	1735	86.7	1750	87.5	x	
6	1980	1815	91.7	1700	85.9	x	
7	1975	1735	87.8	1715	86.8	x	
8	1980	1825	92.2	1815	91.7	x	
Total	7935	7110		6980			
Average	1984	1778	89.6	1745	88.0		



a. Top Pulley



b. Bottom Pulley

Figure 43. Code E Stainless Steel Cable Endurance-Tested at +70°F to MIL-C-5424A-1

APPENDIX VII

DETAILED TEST DATA FOR CODE F

(Tables XXXIX through XLIV and Figures 44 through 49)

In the figures for the -65°F tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 1

Sample 2

Sample 3

Sample 4

In the figures for the $+70^{\circ}\text{F}$ tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 5

Sample 6

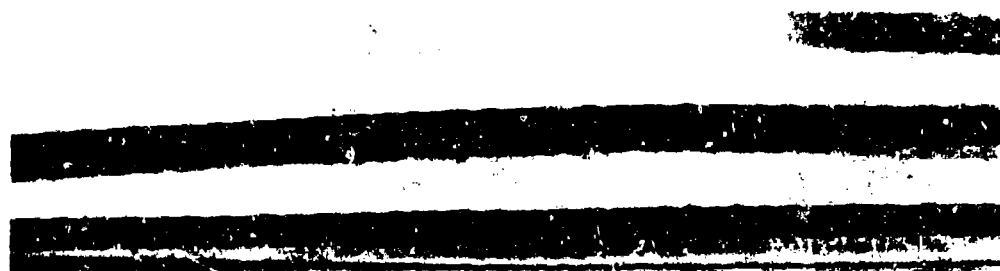
Sample 7

Sample 8

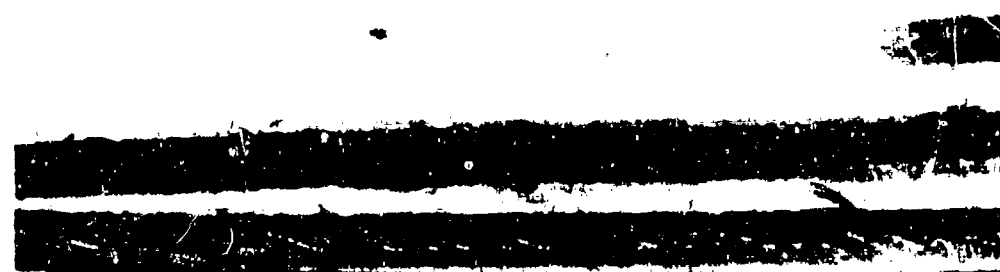
TABLE XXXIX

BREAKING STRENGTH OF CODE F GALVANIZED STEEL CABLES BEFORE AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2200	Cables completely separated at 32,000 reversals. Tests for these cables were terminated.					x
2	2225						x
3	2300	645	28.0	460	20.0		x
4	2225	505	22.7	470	21.1		x
Total	8950	1150		930			
Average	4525	575	25.4	465	20.5		



a. Top Pulley



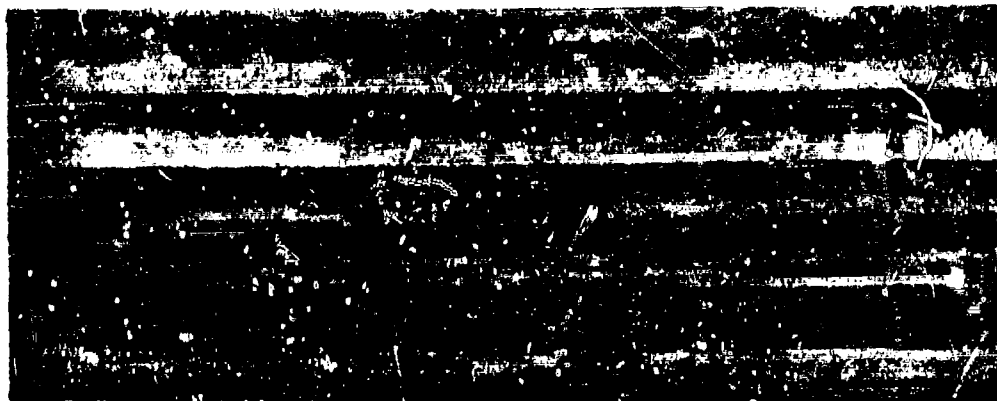
b. Bottom Pulley

Figure 44. Code F Galvanized Cable Endurance-Tested at -65°F to MIL-W-15511A-4

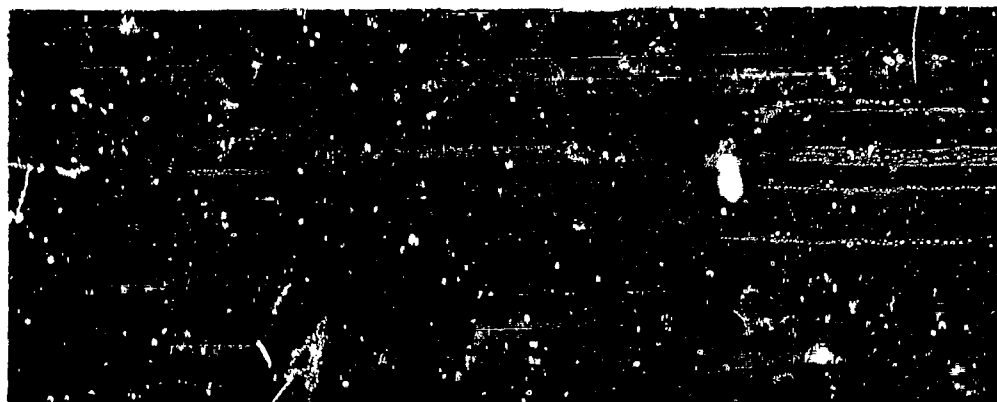
TABLE XL

BREAKING STRENGTH OF CODE F GALVANIZED STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2200	1825	83.0	1515	68.9	x	
6	2225	1680	75.5	1710	76.9	x	
7	2300	1510	65.7	1715	74.6	x	
8	2225	1745	78.4	1720	77.3	x	
Total	8950	6760		6660			
Average	2238	1690	75.5	1665	74.4		



a. Top Pulley



b. Bottom Pulley

Figure 45. Code F Galvanized Cable Endurance-Tested at +70°F to MIL-W-1511A-4

TABLE XLI

**BREAKING STRENGTH OF CODE F STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4**

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2150	605	28.1	1260	58.6		x
2	2140	855	40.0	1070	50.0		x
3	2160	1430	66.2	1140	52.8	x	
4	2140	1350	63.1	1485	69.4	x	
Total	8590	4240		4955			
Average	2148	1060	49.4	1239	57.7		



a. Top Pulley



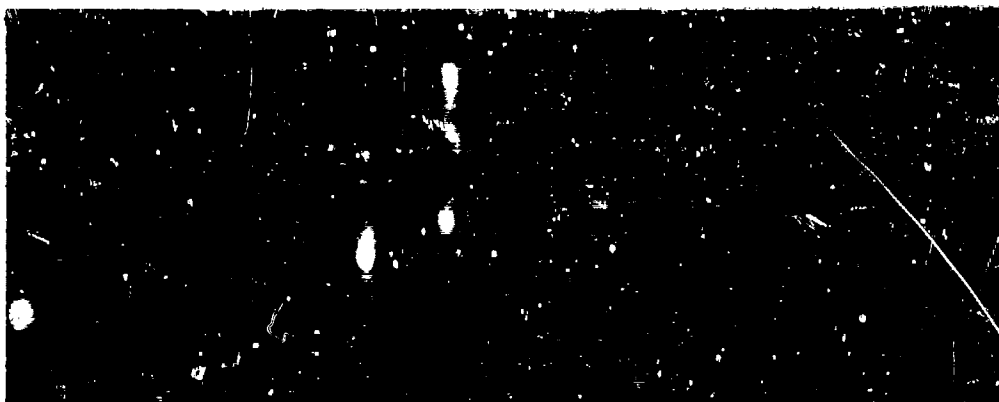
b. Bottom Pulley

Figure 46. Code F Stainless Steel Cable Endurance-Tested at -65°F to MIL-W-1511A-4

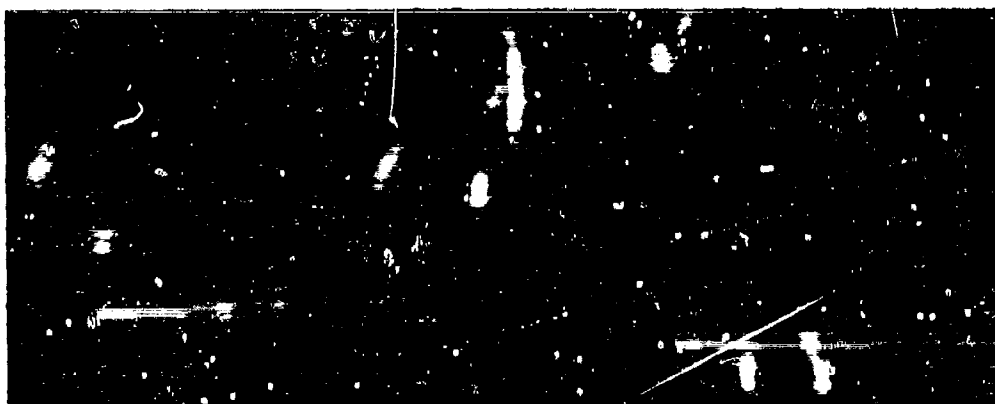
TABLE XLII

BREAKING STRENGTH OF CODE F STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2150	1150	53.5	1445	67.2	x	
6	2140	1525	71.3	1620	75.7	x	
7	2160	1375	63.7	1075	49.8	x	
8	2140	1420	66.4	1245	58.2	x	
Total	8590	5470		5385			
Average	2148	1368	63.7	1346	62.7		



a. Top Pulley



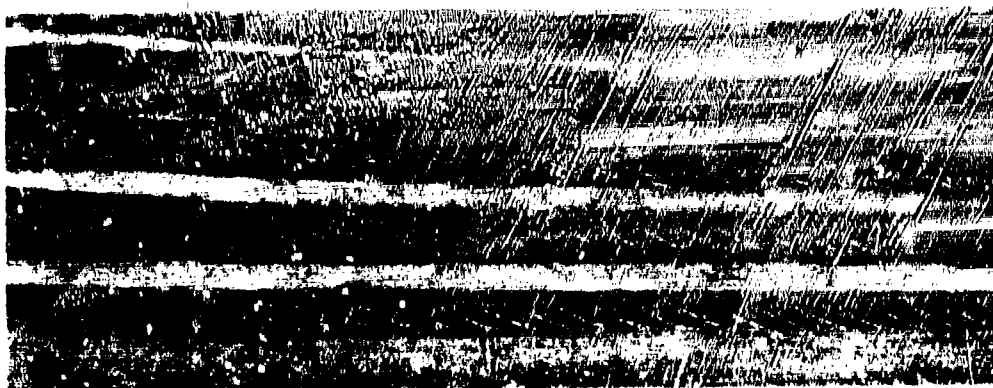
b. Bottom Pulley

Figure 47. Code F Stainless Steel Cable Endurance-Tested at +70°F to MIL-W-1511A-4

TABLE XLIII

BREAKING STRENGTH OF CODE F STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-C-5424A-1

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2150	1800	83.7	1735	80.7	x	
2	2140	1890	88.3	1805	84.3	x	
3	2160	1870	86.6	1910	88.4	x	
4	2140	1760	82.2	1875	87.6	x	
Total	8590	7320		7325			
Average	2148	1680	85.2	1831	85.3		



a. Top Pulley



b. Bottom Pulley

Figure 48. Code F Stainless Steel Cable Endurance-Tested at -65°F to MIL-C-5424A-1

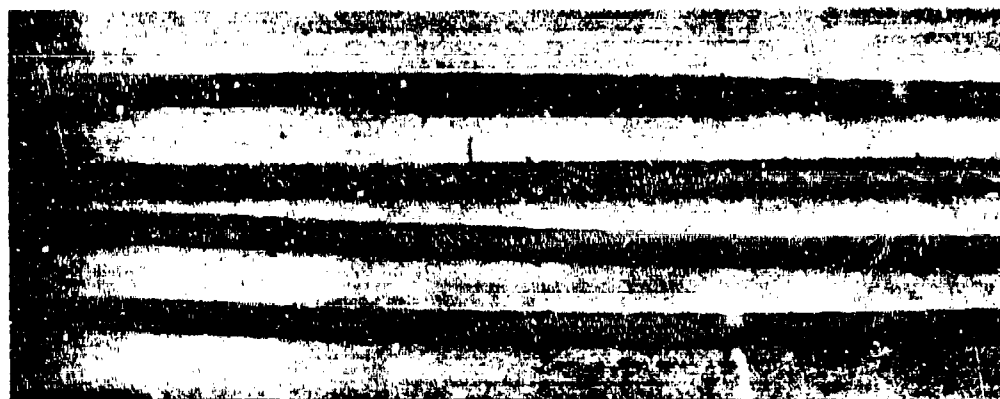
TABLE XLIV

BREAKING STRENGTH OF CODE F STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-C-5424A-1

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1700 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTON PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2150	1850	86.0	1870	87.0	x	
6	2140	1905	89.0	1765	82.3	x	
7	2160	1825	84.5	1825	84.5	x	
8	2140	1810	84.6	1890	88.3	x	
Total	8590	7390		7350			
Average	2148	1848	86.0	1838	85.6		



a. Top Pulley



b. Bottom Pulley

Figure 49. Code F Stainless Steel Cable Endurance-Tested at +70°F to MIL-C-5424A-1

APPENDIX VIII

DETAILED TEST DATA FOR CODE G

(Tables XLV through L and Figures 50 through 54)

Since galvanized samples failed the low temperature tests, no figures are included for these samples.

In the figures for the -65°F tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 1

Sample 2

Sample 3

Sample 4

In the figures for the $+70^{\circ}\text{F}$ tests, the cables are arranged in the following descending order for Parts a and b of each figure:

Sample 5

Sample 6

Sample 7

Sample 8

TABLE XLV

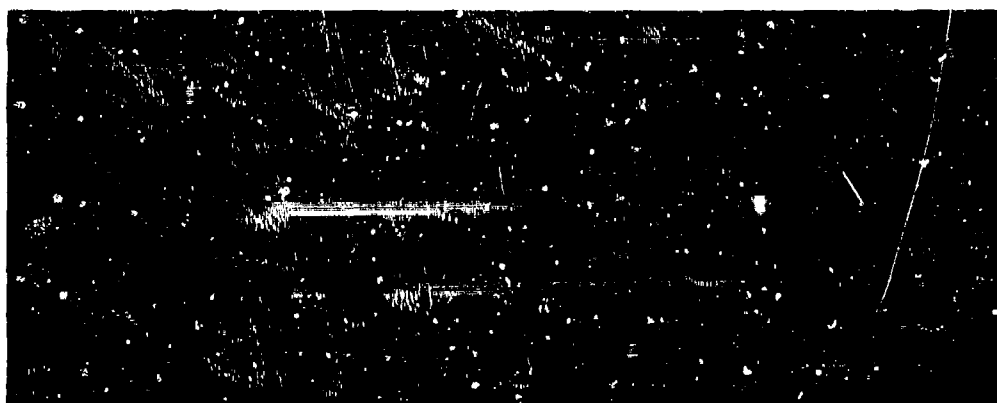
**BREAKING STRENGTH OF CODE G GALVANIZED STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4**

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1900 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2110	Cables completely separated at 26,000 reversals. Tests for these cables were terminated.					x
2	2160						x
3	2120						x
4	2160						x
Total	8550						
Average	2137						

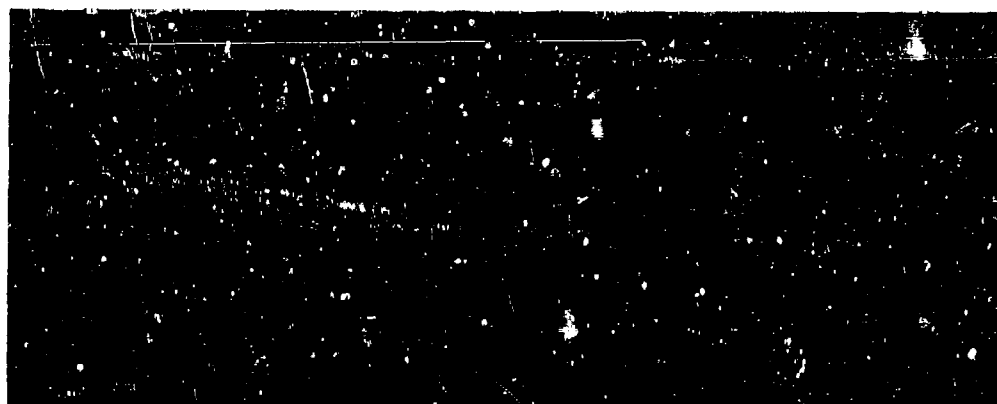
TABLE XLVI

BREAKING STRENGTH OF CODE G GALVANIZED STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (2000 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (1000 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2110	1380	65.4	1765	83.6	x	
6	2160	1800	83.3	1720	79.6	x	
7	2120	1880	88.7	1740	82.1	x	
8	2160	1600	74.1	1765	81.7	x	
Total	8550	6660		6990			
Average	2138	1665	77.9	1748	81.8		



a. Top Pulley



b. Bottom Pulley

Figure 50. Code G Galvanized Cable Endurance-Tested at +70°F to MIL-W-1511A-4

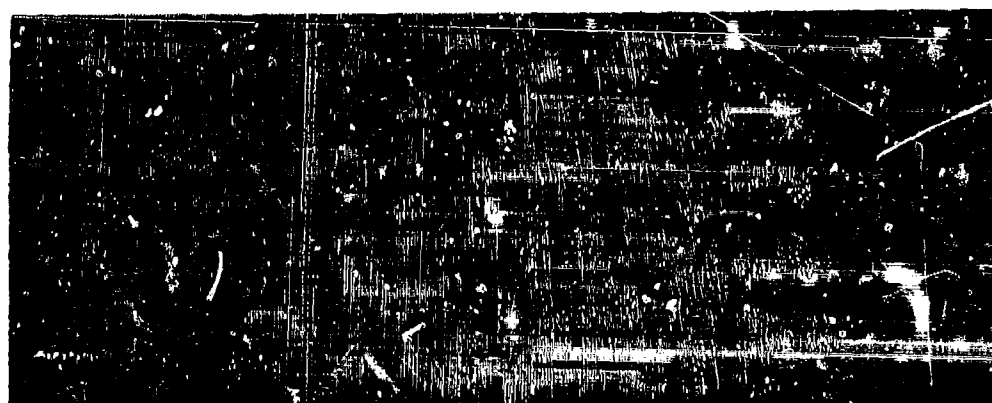
TABLE XLVII

**BREAKING STRENGTH OF CODE G STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-W-1511A-4**

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2050	1050	51.2	1250	61.0	x	x
2	2020	850	42.1	1225	60.6		
3	2065	1250	60.5	1270	61.5	x	
4	2020	1485	56.8	1135	56.2	x	
Total	8155	4635		4880			
Average	2039	1159	56.8	1220	59.8		



a. Top Pulley



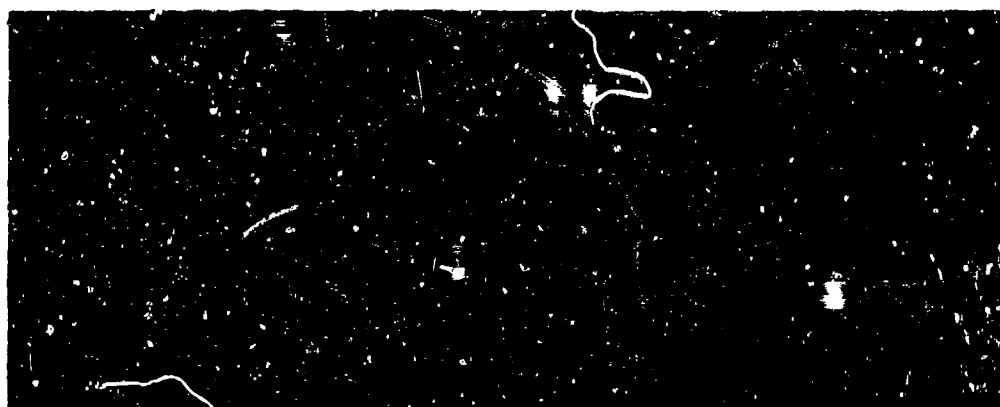
b. Bottom Pulley

Figure 51. Code G Stainless Steel Cable Endurance-Tested at -65°F to MIL-W-1511A-4

TABLE XLVIII

BREAKING STRENGTH OF CODE G STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-W-1511A-4

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2050	1275	62.2	1070	52.2	x	
6	2020	1260	62.4	1095	54.2	x	
7	2065	1175	56.9	1220	59.1	x	
8	2020	1275	63.1	1215	60.1	x	
Total	8155	4985		4600			
Average	2039	1246	61.1	1150	56.4		



a. Top Pulley



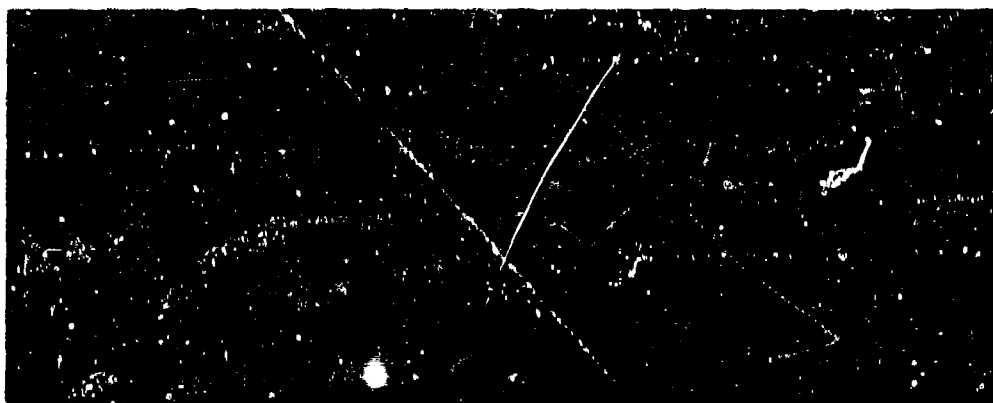
b. Bottom Pulley

Figure 52. Code G Stainless Steel Cable Endurance-Tested at +70°F to MIL-W-1511A-4

TABLE XLIX

BREAKING STRENGTH OF CODE G STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT -65°F TO MIL-C-5424A-1

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTON PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
1	2050	1675	81.7	1780	86.8	x	
2	2020	1835	90.8	1850	91.6	x	
3	2665	1675	81.1	1800	87.2	x	
4	2020	1725	85.4	1750	86.2	x	
Total	8155	6910		7180			
Average	2039	1728	84.7	1795	88.0		



a. Top Pulley



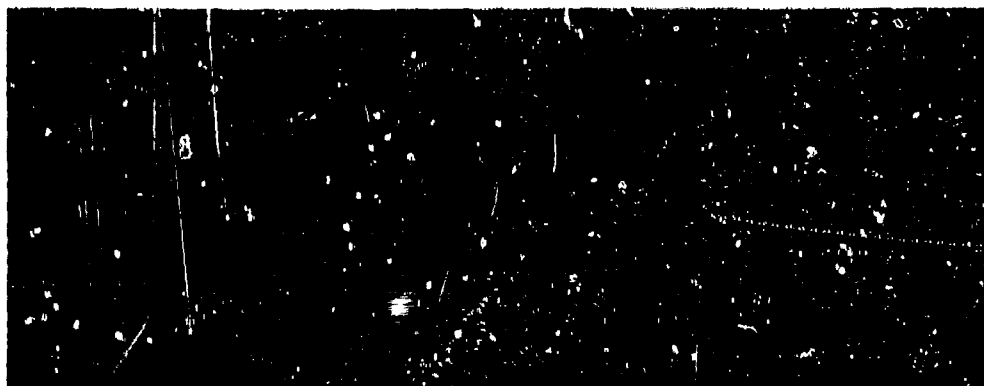
b. Bottom Pulley

Figure 53. Code G Stainless Steel Cable Endurance-Tested at -65°F to MIL-C-5424A-1

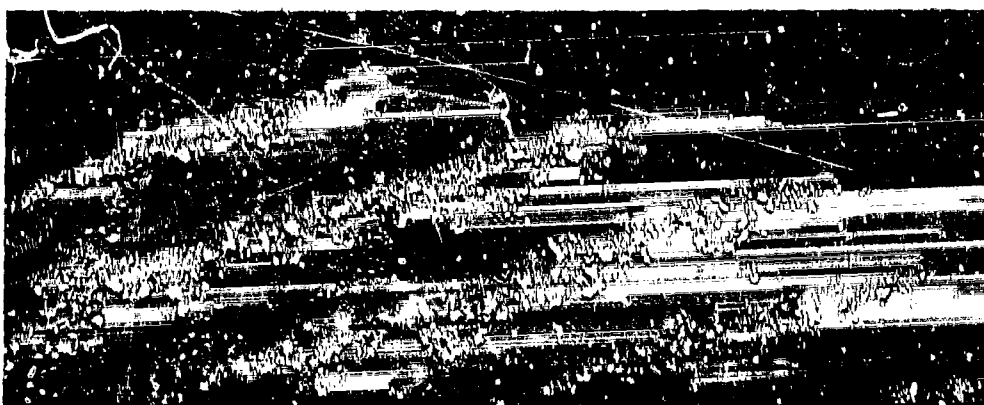
TABLE L

BREAKING STRENGTH OF CODE G STAINLESS STEEL CABLES BEFORE
AND AFTER ENDURANCE TESTING AT +70°F TO MIL-C-5424A-1

SAMPLE NO.	POUNDS BEFORE ENDURANCE TESTING (1760 LBS REQUIRED BY SPECIFICATION)	BREAKING STRENGTH AFTER ENDURANCE TESTING (950 LBS REQUIRED BY SPECIFICATION)				PASSED	FAILED
		TOP PULLEY		BOTTOM PULLEY			
		POUNDS	PERCENT REMAINING	POUNDS	PERCENT REMAINING		
5	2050	1875	91.5	1840	89.6	x	
6	2020	1825	90.3	1825	90.3	x	
7	2065	1815	87.9	1775	86.0	x	
8	2020	1800	89.1	1825	90.3	x	
Total	8155	7315		7265			
Average	2039	1829	89.7	1816	89.1		



a. Top Pulley



b. Bottom Pulley

Figure 54. Code G Stainless Steel Cable Endurance-Tested at +70°F to MIL-C-5424A-1

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Systems Engineering Group Wright-Patterson Air Force Base, Ohio 45433	
13. ABSTRACT <p>Because of recent high rejection rates on carbon steel control cables on military aircraft, the Air Force conducted breaking strength and endurance tests on various types of aircraft control cables. Since approximately 90% of the service life of jet aircraft is flown at low temperatures, the primary purpose of the tests was to obtain information on cable fatigue life at low temperature. The tests were conducted on 1/8-inch diameter 7x19 galvanized carbon steel, tin-coated carbon steel, and stainless steel cables at both low temperature (-65°F) and room temperature (+70°F). The tests were conducted in the Climatic Laboratory at Eglin AFB, Florida. Results indicate that the stainless steel cables are far superior to the galvanized or tin-coated cables for low temperature operation. Therefore, the stainless steel cables should be considered for replacement of the carbon steel control cables on military aircraft, and the appropriate specifications should be updated accordingly.</p> <p>(This abstract is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of the Directorate of Airframe Subsystems Engineering (SEFL), Systems Engineering Group, Wright-Patterson Air Force Base, Ohio.)</p>		

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14- KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Low-Temperature Fatigue Tests of Aircraft Control Cables						
Aircraft Control Cables						

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